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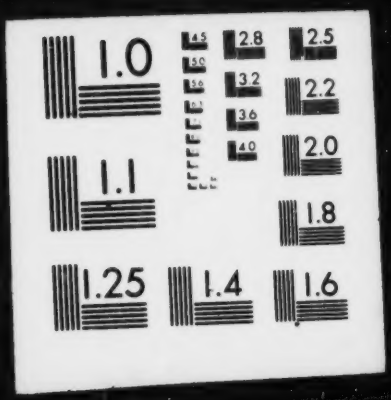

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AREA SOURCE EMISSION INVENTORY FOR CHATHAM COUNTY, GEORGIA. VOLUME I

PEDCO-Environmental Specialists, Incorporated

Prepared for:

Environmental Protection Agency

October 1975

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AREA SOURCE EMISSION INVENTORY FOR CHATHAM COUNTY - GEORGIA

Volume I

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16. Abstracts

This project was undertaken to prepare an inventory of area sources of particulates, SO_x, CO, HC, and NO_x emissions in the Savannah area for use in analysis and modeling of air quality in this designated Air Quality Maintenance Area for the period 1975-1985. Base year (1973) emissions are projected to 1975, 1980, and 1985, as specified in EPA's regulations governing the preparation of Air Quality Maintenance Plans. Total emissions in thirty categories, including fugitive dust, were allocated into grid squares covering the entire area. The emissions for each grid were estimated by use of EPA's "Area-2 Program." Required input data for this program, aside from pertinent grid information, are fuel usage totals and emission factors. The program was modified by PEDCo to accept data input from up to twenty-five source categories requiring both emission calculation and apportioning, and from ten other categories which are best treated as "point sources."

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AREA SOURCE EMISSION INVENTORY FOR CHATHAM COUNTY - GEORGIA

Volume I

Prepared by

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Suite 13, Atkinson Square
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Contract No. 68-02-1375
Task Order No. 9

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Region IV, Atlanta, Georgia

Georgia Department of Natural Resources
Environmental Protection Division

October 1975

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This report was prepared for the U.S. Environmental Protection Agency by PEDCo-Environmental Specialists, Inc., Cincinnati, Ohio. Mr. Edwin Pfetzing was the PEDCo Project Manager. The principal author of the report was Mr. Stephen Walsh.

Mr. Randy Mayfield was the Project Officer for the U.S. Environmental Protection Agency. The project team is appreciative of the assistance and cooperation extended by Mr. Mayfield, other staff members of EPA Region Office IV, and Mr. James Mullins, Georgia Department of Natural Resources.

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1. INTRODUCTION

This project was undertaken to prepare an inventory of area sources of air pollutant (particulate, SO_x, CO, HC, NO_x) emissions in Chatham County for use in analysis and modeling of air quality in this designated Air Quality Maintenance Area (AQMA) for the period 1975 to 1985. A base year of 1973 was specified for the inventory because this is the most recent year for which much of the published national, state, and local data were available.

The base year area source emissions are projected to three different future years--1975, 1980, and 1985--as part of this project. These analysis years are specified in the EPA regulations on preparation of AQMA plans.

The area covered by this study is comprised of Chatham County in its entirety, including Savannah and seven other incorporated municipalities within its boundaries, representing a total land area of 455 square miles.

The area is marked by level topography and low elevations; the highest elevation within Chatham County is approximately 50 feet above mean sea level. Approximately 40 percent of the total land area of Chatham County is marshland. Much of the highland within the county is forested, and numerous swamps, creeks and rivers are predominant features.

The climate within the study area is temperate, with a mean annual temperature of about 65°F. Prevailing wind directions

are generally southwesterly during the summer months, northeasterly during the autumn months through December, and varying but predominately northwesterly from January through April.

The Air Pollution Control Section of Chatham County Health Department conducted an air pollutant emission inventory for Savannah and Chatham County in 1968. The categories covered were:

1. Fuel combustion in transportation vehicles,
2. Fuel combustion in stationary sources,
3. Combustion of refuse,
4. Industrial processes.

The pollutants inventoried were aldehydes, carbon monoxide, hydrocarbons, nitrogen oxides, sulfur oxides, particulates, organic acids, ammonia, and hydrogen fluorides. The data in the report shows that the predominant sources of pollutants are industrial processes.

This inventory does not take into account industrial processes or other point sources. However, the vast number of area sources, essentially uncontrolled, suggests that continued attention be directed to the expected increasing ratio of area source to point source emissions.

A comparison of the relative magnitudes of the emissions accounted for in the 1968 Health Department inventory with those of this inventory and the 1973 point source emissions is presented in Chapter 2.

2. SUMMARY

Total emissions from fuel usage are summarized by area source category for the base year and three projection years in Tables 2-1 to 2-4. The appropriate category descriptor codes are listed in Table 2-5. This list of categories was compiled at the initial project meeting of the participants (EPA - Region IV, Georgia DNR, and PEDCo). It is conventional except for the four fugitive dust source categories.

Survey data, emission estimating procedures, and projection techniques that were used to calculate these values for each source category are documented in detail in Chapters 3 through 7 of this report.

A source category not originally intended for inclusion herein, but which is receiving increased attention, is fugitive dust from paved roads. An accurate quantification of the contribution from this source was difficult. It has, however, been evaluated for its estimated impact on air quality and is discussed as an additional fugitive dust source in Chapter 7. Summary Tables 2-1 to 2-4 include this source as an additional category after subtotalling all other area source emissions.

The procedures used to allocate emissions for each area source category to the grid cells are also explained in detail in subsequent sections. The resulting emissions by grid for 1973, 1975, 1980, and 1985 are presented in the

Table 1-1. TOTAL EMISSIONS FROM FUEL USAGE BY SOURCE CATEGORY - 1973 (ton/yr)

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
RESCOAL	161.0	TCF/YR	1.2	2.5	4.0	0.9	0.4
RESFUL	1626.0	10**3 GAL/YR	8.1	50.3	4.1	2.6	9.8
RESGAS	3617.0	10**6 CU FT/YR	18.1	1.1	36.2	14.5	144.7
RESLPG	2485.0	10**3 GAL/YR	2.3	0.0	2.4	0.9	9.3
COMCOAL	1117.0	TCF/YR	21.3	17.4	3.4	1.1	5.9
COMFUL	4007.0	10**3 GAL/YR	53.0	688.5	9.2	6.9	139.2
COMGAS	4376.0	10**3 GAL/YR	32.8	135.4	8.8	6.4	131.3
COMLPG	1891.0	10**6 CU FT/YR	9.4	0.6	18.8	7.5	112.9
INDCOAL	3073.0	10**3 GAL/YR	2.8	0.9	3.1	1.2	17.7
INDFUL	6695.0	TCF/YR	335.1	132.0	4.5	2.2	33.6
INDGAS	0.0	10**3 GAL/YR	0.0	0.0	0.0	0.0	0.0
INDLPG	1653.0	10**3 GAL/YR	12.4	57.6	3.3	2.5	49.6
ELECOAL	36880.0	10**6 CU FT/YR	18.4	1.1	31.3	5.5	327.7
ELCLPG	304.0	10**3 GAL/YR	0.3	0.0	0.2	0.0	1.8
WOOD	1044.0	TCF/YR	8.9	0.0	26.1	2.1	1.0
GASMVEH	995.0	10**6 VMT/YR	702.0	179.1	98294.5	14136.0	5363.5
DIEMVEH	30.0	10**6 VMT/YR	60.5	92.5	244.1	76.0	829.3
AVILGC	6685.0	10**3 GAL/YR	81.1	184.8	421.5	334.8	1199.7
JLSVFSL	3545.0	10**3 GAL/YR	0.0	12.8	6575.3	2191.8	13.2
OFHTVEH	5884.0	10**3 GAL/YR	73.3	51.1	4671.9	934.1	797.9
OFFROAD	22862.0	TCF/YR	191.1	2.3	699.0	163.6	34.3
AIRCRAF	19568.0	TON/YR	166.3	0.0	1369.8	234.8	39.1
EVAPLOS	257631.0	TCF/YR	0.0	0.0	0.0	2247.1	0.0
RFUPROD	1363.0	10**3 VMT/YR	2405.7	0.0	0.0	0.0	0.0
RFRAVRC	1025.0	10**6 VMT/YR	1380.2	0.0	0.0	0.0	0.0

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Table 1-1 (continued). TOTAL EMISSIONS FROM FUEL USAGE BY SOURCE CATEGORY - 1973 (ton/yr)

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
AIRPORT	602.4.0	LTC/YR	20.0	16.5	603.3	145.3	113.4
RAILROAD	50?.0.0	TCA/YR	17.4	0.4	25.1	7.2	7.3
COAL-FIL	1?00.0	ACFE/YR	46.5	0.3	0.0	0.0	0.0
FORCAST	0.0	ACFE/YR	0.0	0.0	0.0	0.0	0.3
CHEMICAL	485431.0	VFS-MI/YR	67.8	1100.1	121.2	80.6	687.1
SUBTOTAL			4356.7				
FORARD			1380.2				
TOTAL			5736.9	2776.1	113221.1	20545.6	10070.2

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Table 1-2. TOTAL EMISSIONS FROM FUEL USAGE BY SOURCE CATEGORY - 1975 (ton/yr)

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
RESCOAL	191.0	TON/YR	0.8	1.6	2.5	0.6	0.2
RESOIL	1378.0	10**3 GAL/YR	7.0	43.3	3.5	2.1	8.4
RESGAS	3726.0	10**6 CU FT/YR	18.6	1.1	37.3	14.9	149.0
RESLPG	270.0	10**3 GAL/YR	2.6	0.0	2.7	1.0	10.4
COMCOAL	1195.0	TON/YR	22.8	18.6	3.6	1.2	6.3
COMOIL	4929.0	10**3 GAL/YR	56.7	736.6	9.9	7.4	147.9
COMOIL	4062.0	10**3 GAL/YR	35.1	144.9	9.4	7.0	140.5
COMGAS	1481.0	10**6 CU FT/YR	5.4	0.6	18.8	7.5	112.9
COMLPG	328.0	10**3 GAL/YR	3.0	0.0	3.3	1.3	13.9
INDCOAL	4986.0	TON/YR	365.2	143.9	4.9	2.4	30.6
INDOIL	0.0	10**3 GAL/YR	0.0	0.0	0.0	0.0	0.0
INDOIL	1302.0	10**3 GAL/YR	13.5	106.4	3.6	2.7	54.1
INDGAS	3588.0	10**6 CU FT/YR	18.4	1.1	31.3	5.5	322.7
INDLPG	331.0	10**3 GAL/YR	0.3	0.0	0.3	0.0	1.9
WOOD	669.0	TON/YR	5.7	0.0	16.7	1.3	0.7
GASVEH	1075.0	10**6 VMT/YR	758.4	184.2	92937.5	13141.3	5801.2
DIESVEH	32.0	10**6 VMT/YR	64.6	98.7	303.1	91.1	884.6
RAILLOC	6485.0	10**3 GAL/YR	81.1	184.8	421.5	334.8	1199.7
RESVESL	4065.0	10**3 GAL/YR	0.0	13.0	6707.3	2235.8	13.4
OFHIVEH	6302.0	10**3 GAL/YR	74.7	60.3	4765.6	922.2	813.9
OFFAIR	21967.0	TON/YR	183.4	7.2	671.1	157.1	33.0
FRAGAIR	19431.0	TON/YR	165.2	0.0	1360.2	233.2	38.9
EVAPLOS	335372.0	TON/YR	0.0	0.0	0.0	2303.3	0.0
EQUAPPD	1227.0	10**3 VMT/YR	2165.7	0.0	0.0	0.0	0.0
EQPAVRD	1107.0	10**6 VMT/YR	1490.6	0.0	0.0	0.0	0.0

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Table 1-2 (continued). TOTAL EMISSIONS FROM FUEL USAGE BY SOURCE CATEGORY - 1975 (ton/yr)

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
AIRCRAFT	170220.0	LTO/YR	29.4	24.5	888.0	223.5	174.3
INCINERA	5084.0	TON/YR	17.9	6.4	25.1	7.2	7.3
FOAGTIL	1730.0	ACRE/YR	46.9	0.0	0.0	0.0	0.0
FORCUST	0.0	ACRE/YR	0.0	0.0	0.0	0.0	0.0
CMSERVES	524715.0	VES-MI/YR	71.0	1195.7	122.0	82.8	718.0
SUBTOTAL			4217.4				
FEPAVED			1490.6				
TOTAL			5708	2962.9	108349.2	19757.2	10694.8

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Table 1-3. TOTAL EMISSIONS FROM FUEL USAGE BY SOURCE CATEGORY - 1980 (ton/yr)

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
RESCOAL	32.9	TON/YR	0.2	0.5	0.8	0.2	0.1
RESDIL	943.3	10**3 GAL/YR	4.7	29.2	2.4	1.4	5.7
RESGAS	3679.0	10**6 CU FT/YR	19.9	1.2	39.8	15.9	159.2
RESLPG	367.0	10**3 GAL/YR	3.4	0.0	3.6	1.4	13.8
COMCOAL	1461.0	TON/YR	27.5	22.5	4.3	1.4	7.6
COMDIL	5943.3	10**3 GAL/YR	68.3	808.2	11.9	8.9	178.3
COMRDIL	5445.0	10**3 GAL/YR	42.3	174.7	11.3	8.5	169.3
COMGAS	1881.0	10**6 CU FT/YR	9.4	0.6	18.8	7.5	112.9
COMLPG	396.0	10**3 GAL/YR	3.6	0.0	4.0	1.6	22.8
INDCOAL	4231.0	TON/YR	465.8	183.5	6.2	3.1	46.7
INDDIL	0.0	10**3 GAL/YR	0.0	0.0	0.0	0.0	0.0
INDRDIL	2298.0	10**3 GAL/YR	17.2	135.7	4.6	3.4	68.9
INDGAS	7628.0	10**6 CU FT/YR	18.4	1.1	31.3	5.5	322.7
INDLPG	423.0	10**3 GAL/YR	0.4	0.0	0.3	0.1	2.5
WOOD	219.0	TON/YR	1.5	0.0	5.5	0.4	0.2
GASVEH	1264.0	10**6 VMT/YR	891.8	222.5	64870.4	9327.1	5289.8
DIEVEH	38.9	10**6 VMT/YR	76.7	117.2	359.9	96.3	1012.8
RAILROD	6425.0	10**3 GAL/YR	81.1	184.8	421.5	304.8	1199.7
PLSVESL	4224.0	10**3 GAL/YR	0.0	13.5	6969.6	2323.2	13.9
CRMIVEH	6237.0	10**3 GAL/YR	77.7	62.7	4952.2	958.3	845.7
OPENPLR	19997.0	TON/YR	166.2	2.0	608.2	142.3	29.0
RRACHW	14765.0	TON/YR	159.7	0.0	1314.9	225.4	37.6
AVAFLGS	336323.0	TON/YR	0.0	0.0	0.0	2539.2	0.0
FLWOOD	487.0	10**3 VMT/YR	1563.8	0.0	0.0	0.0	0.0
RDRAVRD	1302.0	10**6 VMT/YR	1753.1	0.0	0.0	0.0	0.0

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Table 1-3 (continued). TOTAL EMISSIONS FROM FUEL USAGE BY SOURCE CATEGORY - 1980 (ton/yr)

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
AIRCRAFT	249322.3	LTO/YR	52.3	43.9	1582.5	414.3	321.7
LOCOMOTIVES	5384.0	TONS/YR	17.9	0.4	25.1	7.2	7.3
BOATTIE	1530.0	ACRE/YR	42.2	0.0	0.0	0.0	0.0
PEDCOST	0.0	ACRE/YR	0.0	0.0	0.0	0.0	0.0
CMSSAVES	621342.0	VES-MI/YR	7[illegible].0	1399.8	124.7	88.3	795.9
SUBTOTAL			3891.3				
FORARD			1753.1				
TOTAL			5644.4	3490	81373.8	16485.7	10665

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Table 1-4. TOTAL EMISSIONS FROM FUEL USAGE BY SOURCE CATEGORY - 1985 (ton/yr)

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
RESCOAL	11.0	TON/YR	0.1	0.2	0.3	0.1	0.0
RESFOIL	634.0	10**3 GAL/YR	3.2	19.6	1.6	1.0	3.8
RESNGAS	438.0	10**6 CU FT/YR	21.3	1.3	42.7	17.1	170.7
RESLPG	486.0	10**3 GAL/YR	4.5	0.0	4.7	1.8	18.2
COMCOAL	1754.0	TON/YR	33.5	27.4	5.3	1.8	9.2
COMFOIL	7237.0	10**3 GAL/YR	83.2	1081.0	14.5	10.8	217.0
COMFOIL	6470.0	10**3 GAL/YR	51.5	212.6	13.7	10.3	206.1
COMNGAS	1461.0	10**6 CU FT/YR	9.4	0.6	18.8	7.5	112.9
COMLPG	485.0	10**3 GAL/YR	4.3	0.0	4.8	1.9	27.7
INDCOAL	7531.0	TON/YR	562.9	221.8	7.5	3.8	56.5
INDFOIL	0.0	10**3 GAL/YR	0.0	0.0	0.0	0.0	0.0
INDFOIL	2777.0	10**3 GAL/YR	20.8	164.0	5.6	4.2	83.3
INDNGAS	3698.0	10**6 CU FT/YR	18.4	1.1	31.3	5.5	322.7
INDLPG	511.0	10**3 GAL/YR	0.5	0.0	0.4	0.1	3.0
WOOD	63.0	TON/YR	0.5	0.0	1.6	0.1	0.1
GASMVEH	1363.0	10**6 VMT/YR	961.6	239.9	38127.9	4803.2	3753.0
DIEMVEH	41.0	10**6 VMT/YR	82.7	120.4	388.3	103.9	1137.9
RAILLOC	6485.0	10**3 GAL/YR	81.1	184.8	421.5	304.8	1199.7
RLSVESL	4463.0	10**3 GAL/YR	0.0	14.3	7363.9	2454.6	14.7
OFHIVEH	6590.0	10**3 GAL/YR	82.0	66.2	5232.5	1012.6	893.6
OFFHWDR	17340.0	TON/YR	145.2	1.7	531.3	124.3	26.1
FRACHDR	14198.0	TON/YR	154.7	0.0	1273.9	218.4	36.4
EVAPLOS	369062.0	TON/YR	0.0	0.0	0.0	2786.4	0.0
BOUSDOC	545.0	10**3 VMT/YR	961.9	0.0	0.0	0.0	0.0
OFFAVOR	1404.0	10**6 VMT/YR	1890.5	0.0	0.0	0.0	0.0

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Table 1-4 (continued). TOTAL EMISSIONS FROM FUEL USAGE BY SOURCE CATEGORY - 1985 (ton/yr)

SOURCE CATEGORY	FUEL USAGE	INPUT UNITS	PARTICULATES	SULFUR OXIDES	CARBON MONOXIDE	HYDROCARBONS	NITROGEN OXIDES
AIRCRAFT	3[illegible]22.0	LTO/YR	67.0	58.4	2029.1	536.5	416.1
RAILROAD	538[illegible].0	TON/YR	17.5	6.4	25.1	7.2	7.3
COASTAL	1360.0	BBL/YR	37.5	0.0	0.0	0.0	0.0
RECREATIONAL	0.0	BBL/YR	0.0	0.0	0.0	0.0	0.0
RESIDENTIAL	71[illegible]3[illegible].0	MBTU/YR	57.2	1614.1	128.4	93.4	374.2
SUBTOTAL			3492.9				
FORAGED			1890.5				
TOTAL			5383.4	4039.8	55674.7	12511.3	9590.1

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Table 2-5. SOURCE CATEGORY DESCRIPTOR CODES

Code	Source category
RESCOAL	Residential coal
RESFOIL	Residential fuel oil
RESNGAS	Residential natural gas
RESLPG	Residential LPG
COMCOAL	Commercial-Institutional coal
COMROIL	Commercial-Institutional residual oil
COMDOIL	Commercial-Institutional distillate oil
COMNGAS	Commercial-Institutional natural gas
COMLPG	Commercial-Institutional LPG
INDCOAL	Industrial coal
INDROIL	Industrial residual oil
INDDOIL	Industrial distillate oil
INDNGAS	Industrial natural gas
INDLPG	Industrial LPG
WOOD	Residential wood
GASMVEH	Gasoline motor vehicles
DIEMVEH	Diesel motor vehicles
RAILLOC	Rail locomotive
PLSVESL	Pleasure vessels
OFHIVEH	Off-highway vehicles
OPENBUR	Open burning
FFAGBUR	Forest fires and agricultural burning
EVAPLOS	Evaporative loss sources
FDUNPRD	Fugitive dust - unpaved roads
FDPAVRD	Fugitive dust - paved roads
AIRCRAFT	Aircraft
INCINERA	Incineration
FDAGTIL	Fugitive dust - agricultural tilling
FDCONST	Fugitive dust - construction
CMSEAVES	Commercial/seaport vessels

Appendices (appended in Volume II). This data can be used directly in the AQMA modeling effort for air quality in the Savannah region.

Area sources are a significant component of overall emissions in the AQMA and should have a major impact on air quality. It also appears that this impact may become proportionately larger in the future because emissions from most area source categories do not exhibit a downward trend in 1975 and beyond as point source emissions would be expected to exhibit.

Table 2-6 provides basis for relative comparison of the emissions data compiled by the Chatham County Health Department and that presented in Tables 2-1 to 2-4. If the emissions from industrial processes in the Health Department inventory are subtracted from the totals to render the totals comparable in scope with the current inventory, the resultant emissions are somewhat comparable in magnitude, ranging from 27 to 72 percent of the current values. These differences are most generally explained by the time differential between the studies, the different methodologies applied, and the more comprehensive treatment of the source categories herein.

The accuracy of the data used in compiling this area source inventory has been estimated based upon the level of accuracy and reliability of the contacts made and sources used. Table 2-7 shows PEDCo's assessment of the accuracy (Order 3, highest accuracy) of data used in computing the area-wide emissions, projections, and subarea distribution for each source category. PEDCo has attempted to use the best available data and methods in compiling this area source emission inventory for Chatham County.

Table 2-6. A SUMMARY OF AIR POLLUTION EMISSIONS FROM MAJOR SOURCE CATEGORIES*

	Industrial processes	Fuel use	Transportation	Solid waste disposal	Totals
	ton/yr	ton/yr	ton/yr	ton/yr	ton/yr
Particulates	8,906	534	670	3.5	10,113.5
Sulfur dioxide	1,541	970	511	0.6	3,022.6
Nitrogen oxides	18	2,773	4,425	3.3	7,219.3
Carbon monoxide	No estimate	240	94,856	59.5	95,155.5
Hydrocarbons	No estimate	206	16,185	6.5	16,397.5
Aldehydes	No estimate	208	162	52	422
Organic acids	No estimate	400	225	3.7	628.7
Ammonia	11	No estimate	No estimate	2.0	13
Hydrogen fluoride	1,480	No estimate	No estimate	No estimate	1,480
Totals	11,946	5,331	117,034	131.1	134,452

* Source: Air Pollutant Emission Inventory Report Savannah and Chatham County, Chatham County Health Department, 1968.

Table 2-7. DATA ACCURACY* OF SOURCE CATEGORIES

Chapter	Source category	Area-wide emissions	Projections	Subarea distribution
4	Bituminous coal			
	Residential coal	1	2	3
	Commercial coal	2	2	3
	Industrial coal	2	2	3
4	Fuel oil			
	Residential fuel oil	1	2	3
	Commercial dist. oil	2	2	3
	Industrial dist. oil	2	2	3
	Commercial resid. oil	2	2	3
	Industrial resid. oil	2	-	-
4	Natural gas			
	Residential nat. gas	2	3	3
	Commercial nat. gas	2	3	3
	Industrial nat. gas	2	3	3
4	LPG			
	Residential LPG	2	1	3
	Commercial LPG	2	2	3
	Industrial LPG	2	2	3
4	Wood	1	1	3
5	Gasoline motor vehicles	3	3	3
5	Diesel motor vehicles	3	3	3
5	Aircraft	3	3	3
5	Rail locomotive	2	2	3
5	Vessels	3	3	3
5	Off-highway vehicles	1	1	1
6	Open burning	2	1	1
6	Incineration	3	2	3
6	Forest fires & agricultural burning	3	1	2

Table 2-7 (continued). DATA ACCURACY* OF SOURCE CATEGORIES

Chapter	Source category	Area-wide emissions	Projections	Subarea distribution
7	Evaporative loss sources	1	1	1
7	Fugitive dust - unpaved roads	2	2	2
7	Fugitive dust - paved roads	1	1	1
7	Fugitive dust - agricultural tilling	3	2	2
7	Fugitive dust - construction	-	-	-

*Order 1 least detail and accuracy
2 moderate detail and accuracy
3 most detail and accuracy

3. GENERAL METHODOLOGY

The following describes the data, references, assumptions, and calculations used to estimate area source pollutant emissions for each of the 30 categories in the inventory. A separate subsection is provided for each source category. For each source category, the text is divided into three parts:

1. estimating area-wide base year emissions,
2. projecting base year emissions to the three future years,
3. allocating emissions to subarea grid cells.

Difficulties were experienced in attempting to project fuel usage, particularly fuel oil and natural gas, because of the many uncertainties at this time surrounding the future availabilities and costs of alternate fuels in the Savannah area. The intermediate-term impacts of energy conservation programs and the current economic recession further clouded the data available for making assumptions and projections. Overall, the increase in total energy consumption represented by the fuel usage increases shown in this report have been estimated in order to, insofar as possible, keep pace with the expected population and industrial-commercial growth and maintain a "worst case" analysis. However, expected reductions in per capita consumption of energy may account for future differences.

In order to input area source emissions into the atmospheric dispersion model for AQMA analysis, the distribution of

these emissions within the study area must be determined. This was accomplished by allocating the total emissions for each category into grid squares covering the entire area, as shown in Figure 3-1. Three grid sizes are used: 2-1/2, 5, and 10 km. This grid system is essentially the same as the one used in the previous inventory, except that some of the original grids are subdivided to give better resolution in the urban fringe areas where growth and development are expected to cause the most extreme changes in emission rates during the 1973 to 1985 period. The new grid system has 57 grids, and Table D-1 summarizes the geographical data pertinent to each.

The "Area-2 Program," originally developed by EPA, was employed to enable rapid, accurate calculation and allocation of emissions. Required input data are fuel usage totals, emission factors, and pertinent grid information. The program was modified by PEDCo to accept data input from up to 25 source categories requiring emission calculation and apportioning and 10 categories which are best treated as "point sources." Additionally, the data output now assumes a completely versatile and informative format, suitable for direct inclusion in this report.

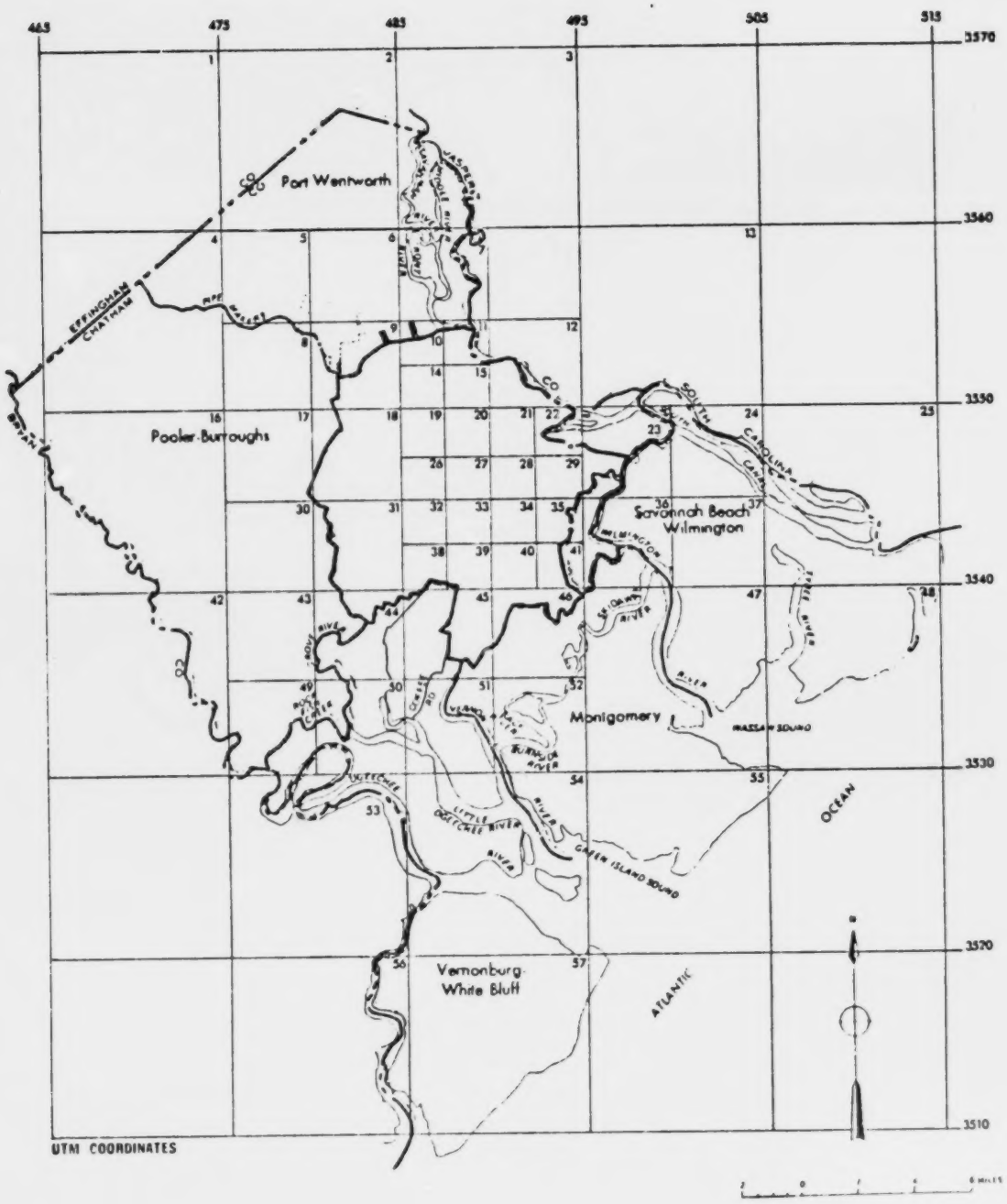

Figure 3-1. Area source grid system for Chatham County.

4. STATIONARY SOURCE FUEL COMBUSTION

BITUMINOUS COAL

Area-wide Emissions

An effort was made to determine coal consumption in Chatham County through contacts with the local coal distributors. Of the companies contacted, only a few were able to provide what they felt was complete and reasonably accurate data. Many were unable to provide the data requested because their sales figures were not computed in coincidence with the geographic boundaries of this study. Some were unwilling to cooperate in providing the requested information.

The methods used to compute coal consumption involved following the procedures outlined in APTD-1135.[1]

Residential (RESCOAL) - Residential coal consumption in 1973 was calculated by the "degree day method," computed as follows:

County	Dwelling units using coal	x	Heating requirement factor[a]	x	Degree days[b] per year	x	$\frac{\text{Rooms}}{\text{D.U.}}\left(\frac{1^c}{5}\right)$	=	Coal usage (ton/yr)
Chatham	84		.0012		1,597		$\frac{5.0}{5.0}$		161.0
References	2,3		1		4		2		

[a] (Ton coal/dwelling unit - degree day)

[b] (The sum of the negative departures of average daily temperature from 65°F)

[c] $\frac{\text{Rooms/dwelling unit - study area}}{\text{5 rooms/dwelling unit - U.S. avg}}$

The total county residential coal consumption is then, 161 ton/yr in 1973.

Commercial-Institutional (COMCOAL) - To obtain commercial-institutional coal consumption, the total state residential consumption must be calculated and subtracted from the total state consumption, the result then apportioned to Chatham County.

Total state dwelling units
using coal in 1970[2] = 24,754

Total state dwelling units
using coal in 1960[3] = 102,626

Extrapolating exponentially with compound interest formula ($S=Pe^{nr}$) to 1973, where, $r = \frac{\ell n\ S/P}{n}$ = -14.22% usage decrease/year.

Therefore,
Total estimated state dwelling
units using coal in 1973 = $S=(24,751)\exp(3)(-0.1422)$
= 16,157

Average annual heating
degree days (average of
Atlanta-2999, Savannah-1597,
Albany-1987)[4] = 2,194

Total state residential
coal consumption = $(16,157)(2,194)(.0012)(\frac{5}{5})$
= 42,538 ton/yr

Then,

State retail dealer's sales[5] = 72,000 ton/yr*

less -

State residential consumption = (-)42,538 ton/yr

Total state commercial - institutional coal usage = 29,462 ton/yr

less-

State commercial-institutional point source coal usage[6] = (-) 3,208 ton/yr (Table C-1)

Total state commercial-institutional area source coal consumption = 26,254 ton/yr

Apportioning to the study area by number of commercial/institutional/government employees:[7,8]

Total county commercial-institutional area source coal consumption = $(26,254)\left(\frac{41,957}{985,800}\right)$

= 1,117 ton/yr

Industrial (INDCOAL) -

Total (GA and FLA) "all other" bituminous coal sales - 1973[5] = 388,000 ton/yr

GA coal usage* = 388,000 ton/yr

less, GA state industrial point source coal usage[6] = (-)261,765 ton/yr (Table C-1)

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* One hundred percent of the GA/FLA total apportioned to GA based on data provided by the Bureau of Mines: In 1974, GA sales = 63.2% of the total and 100% of the "retail dealers" and "all other" categories. It has been assumed that this same distribution prevailed in 1973, when separate GA/FLA sales figures were not calculated. (Personal Communication: Mrs. Dorothy Federoff, U.S. Bureau of Mines, and Mr. N.S. Walsh, PEDCo-Enviornmental, May 4, 1975)

Total state industrial bituminous coal area source usage = 126,235 ton/yr

Apportioning to the study area by number of manufacturing employees (it was assumed that the ratio - $\frac{\text{study area mfg. employees}}{\text{state mfg. employees}}$[7][9] of the 1970 data used was the same as the 1973 ratio),

Total county industrial bituminous coal area source consumption = $(126,235)(\frac{16,875}{475,121})$

= 4,483 ton/yr

The total area source bituminous coal consumption for Chatham county is the sum of the RESCOAL, COMCOAL and INDCOAL categories: 161 + 1,117 + 4,483 = 5,761 ton/yr

Emission factors for the three categories were derived from AP-42[10] and are summarized by source category in Appendix A. Fuel sulfur and ash content were estimated from the average of those categories in the Georgia State SCC Point Source listing (Table C-1).*

Total emissions from these categories in 1973 are presented below and in Table 2-1.

Source category	Total emissions - 1973, ton/yr				
	Partic.	SO_x	CO	HC	NO_x
RESCOAL	1.2	2.5	4.0	0.9	0.4
COMCOAL	21.3	17.4	3.4	1.1	5.9
INDCOAL	335.1	132.0	4.5	2.2	33.6
Totals	357.6	151.9	11.9	4.2	39.9

*Residential & Commercial A 5.1% S .82%
Industrial A 11.5% S 1.55%

Projections

Residential coal usage is steadily declining due to home heating conversions to natural gas and electricity. New homes that use coal as a heating fuel are not being built. Also, coal heated buildings are often quite old and subject to demolition in urban renewal and highway projects. Projections, therefore, were based upon the estimated number of dwelling units using coal in the projection years, derived by the exponential extrapolation method previously described.

In arriving at these values, it was assumed that the number of houses using coal would continue to decline at the same rate/year as was consistent with the 1960-1970 trend, (Appendix B).

Year	1973	1975	1980	1985
No. houses using coal	84	53	17	6
Growth factor	base	0.63	0.20	0.07
RESCOAL consumption (ton/yr)	161	101	32	11

RESCOAL emissions for the projection years are presented in Tables 2-2 to 2-4, assuming that the same emission factors and fuel sulfur and ash contents prevail as in 1973.

Commercial-institutional coal usage in the future was assumed to reflect the economic climate projected for the Savannah air quality control region. U.S. Department of Commerce, Bureau of Economic Analysis (BEA) economic growth projections[11] are presented as the best available indicator of the future economic climate and level of commercial activity at this time. Projected emissions are tabulated in COMCOAL category, Tables 2-2 to 2-4.

Year	1973	1975	1980	1985
Savannah AQCR earnings for wholesale and retail trade, services, and government categories (10^3 1967 $).	(interpolated 646,984	694,100	837,200	1,012,800
Growth factor	base	1.07	1.29	1.57
COMCOAL usage (ton/yr)	1,117	1,195	1,441	1,754

Industrial area source coal consumption, in consonance with commercial-institutional usage, will most probably increase in the future due to the expected continuance of critical supply shortages and higher costs of cleaner burning fuels. In the absence of detailed statistics revealing projected energy market demands, industrial growth has also been estimated based on the BEA projections for all manufacturing industries.[11]

Year	1973	1975	1980	1985
Savannah AQCR mfg. earnings (10^3 1967 $)	(interpolated) 197,063	215,600	274,800	330,300
Growth factor	base	1.09	1.39	1.68
INDCOAL usage (ton/yr)	4,483	4,886	6,231	7,531

INDCOAL emissions for the three future years are presented in Tables 2-2 to 2-4.

Subarea Distribution

Apportioning pollutant emissions from Chatham County's area source bituminous coal combustion to grid cells was based on the following factors for each source category:

RESCOAL	-	No. houses in each grid using (Table B-1) coal
COMCOAL	-	No. commercial/institutional/government employees in each grid[7]
INDCOAL	-	No. manufacturing employees in each grid[7]

Allocated emissions for these categories for all study years are presented in Appendices E through P.*

* Apportioning factors by grid are found in Tables Q-1 to Q-4.

FUEL OIL - DISTILLATE

Area-wide Emissions

A survey of several retail fuel oil dealers in Savannah yielded much the same vague data as determined from contacts with local coal distributors. Since the lack of sales data from any one distributor would render the fuel oil consumption total invalid, this method of determination of fuel oil sales was discontinued.

Residential (RESFOIL) - Consumption of distillate fuel oil in Chatham County by residential heating was calculated by the degree-day method previously described for coal.

County	Dwelling units using oil	x	Heating requirement factor[a]	x	Degree days per year	x	$\frac{\text{Rooms}}{\text{D.U.}}(\frac{1}{5})$ =	Oil usage (10^3 gal/yr)
Chatham	5,655		0.18		1,597		$\frac{5.0}{5.0}$	1,626
References	2,3		1		4		2	

[a] (Gals. oil/dwelling unit-degree day).

The total area source residential distillate oil consumption is 1,626 x 10^3 gal/yr in 1973.

Commercial-Institutional (COMDOIL) - To obtain the commercial-institutional area source distillate oil usage, the following state data were used:

Kerosene used for heating[12]	=	121×10^3 bbl
Distillate type heating oils[12]	=	$2,984 \times 10^3$ bbl
Distillate used by military[12]	=	95×10^3 bbl
Total		$3,200 \times 10^3$ bbl
		$\times$ 42 gal/bbl

Total state commercial-institutional and residential distillate oil consumption = $134,000 \times 10^3$ gal

The state residential distillate oil usage must be subtracted from the above,

Total state dwelling units using distillate oil in 1970[2] = 67,956

Total state dwelling units using distillate oil in 1960[3] = 106,117

Using an exponential extrapolation ($S = Pe^{nr}$) to 1973, where $r = \frac{\ell n\ S/P}{n}$ = (-)4.45% usage decrease/year.

Then,

Total estimated state dwelling units using distillate oil in 1973 = 59,451

Average annual heating degree-days (Avg. of Atlanta, Savannah, Albany)[4] = 2,194

Total state residential distillate oil consumption in 1973 = $(59,451)(2,194)(0.18)(\frac{5}{5})$

= $23,478 \times 10^3$ gal

Then, $134{,}400 \times 10^3$ gal

(-) $23{,}478 \times 10^3$ gal

Total state commercial-institutional distillate oil usage = $110{,}922 \times 10^3$ gal

less, Total state commercial-institutional point source distillate oil usage[6] = (-)$8{,}102 \times 10^3$ gal (Table C-1)

Total state commercial-institutional area source distillate oil usage = $102{,}820 \times 10^3$ gal

Apportioning to Chatham County by number of commercial/institutional/government employees,[7,8]

Total commercial-institutional area source distillate oil consumption in Chatham County (1973) $= (102{,}820)\left(\frac{41{,}957}{985{,}800}\right)$

$= \underline{4{,}376 \times 10^3 \text{ gal/yr}}$

Industrial (INDDOIL) - Industrial consumption of distillate oil was determined using the following state data from Reference 12:

State industrial distillate oil sales = $1{,}584 \times 10^3$ bbl

State sales to oil companies = 56×10^3 bbl

$1{,}640 \times 10^3$ bbl

x 42 gal/bbl

Total state industrial distillate oil usage = $68{,}880 \times 10^3$ gal

Subtracting the industrial point source usage of 22,331 x 10^3 gallons/year[6], (Table C-1) from this amount gives an industrial area source distillate oil consumption of 46,549 x 10^3 gal/yr in the state.

This total, when apportioned to the study area by number of manufacturing employees[7,9] (applying the same assumptions as for coal) equals,

Total county industrial area source distillate oil usage $= (46,549 \times 10^3)\ (\frac{16,875}{475,121})$

$= 1,653 \times 10^3$ gal/yr

The total area source distillate oil consumption for the county is,

Residential	$1,626 \times 10^3$ gal/yr
Commercial-institutional	$4,376 \times 10^3$ gal/yr
Industrial	$1,653 \times 10^3$ gal/yr
Total distillate oil consumption	$7,655 \times 10^3$ gal/yr

Emission factors derived from AP-42 were applied to the fuel totals to calculate emission totals and are summarized in Table A-1. Fuel sulfur and ash contents estimated from the SCC point source printout[6] are indicated in Table C-1.*

The area source pollutant emissions in Chatham County resulting from combustion of distillate oil are:

*Distillate: Res. & Comm. A-%, S. 43%; Industrial A-%, S .82%
Residual: Res. & Comm. A-%, S 1.88%; Industrial A-%, S. 2.04%

Source category	Total emissions - 1973, ton/yr				
	Partic.	SO_x	CO	HC	NO_x
RESFOIL	8.1	50.3	4.1	2.4	9.8
COMDOIL	32.8	135.4	8.8	6.6	131.3
INDDOIL	12.4	97.6	3.3	2.5	49.6
Totals	53.3	283.3	16.2	11.5	190.7

Projections

Distillate fuel oil consumption by the residential sector for the future study years was based on the estimated number of dwelling units using fuel oil for heating. In determining these estimates, it was assumed that the counties' usage rate through 1985 was consistent with the 1960-1970 trend (Appendix B). Given the current supply and demand expectations for the energy market, this appears to be a reasonable forecasting approach.

Year	1973	1975	1980	1985
No. houses using fuel oil	5,655	4,843	3,287	2,231
Growth factor	base	0.86	0.58	0.39
Fuel oil consumption (10^3 gal/yr)	1,626	1,398	943	634

Future RESFOIL pollutant emissions are presented in Tables 2-2 to 2-4, assuming that the same emission factors and fuel sulfur and ash contents prevail as in 1973.

The majority of emissions from this category will result from the commercial-institutional and industrial sectors

where increased fuel oil usage is entirely probable, since natural gas in the Savannah region will be restricted to these users.* For this reason, BEA commercial-institutional growth projections[11] were used to estimate commercial-institutional fuel use for the study years. Projected emissions are tabulated in COMDOIL category, Tables 2-2 to 2-4.

Year	1973	1975	1980	1985
Savannah AQCR earnings for wholesale & retail trade, services, and government categories (10^3 1967 $).	(interpolated) 646,984	694,100	837,200	1,012,800
Growth factor	base	1.07	1.29	1.57
COMDOIL usage (10^3 gal/yr)	4,376	4,682	5,645	6,870

Industrial growth has been estimated based on the BEA projections for all manufacturing industries.

Year	1973	1975	1980	1985
Savannah AQCR mfg. earnings (10^3 1967 $)	(interpolated) 197,063	215,600	274,800	330,300
Growth factor	base	1.09	1.39	1.68
INDDOIL usage (10^3 gal/yr)	1,653	1,802	2,298	2,777

INDDOIL projected emissions are tabulated in Tables 2-2 to 2-4.

* Personal Communication: Mr. James Tate, Atlanta Gas Light Co., Public Relations Dept., and Mr. N.S. Walsh, PEDCo-Environmental, April 30, 1975, May 14, 1975, and June 23, 1975.

Subarea Distribution

Pollutant emissions resulting from area source distillate fuel oil combustion were distributed to all grid cells based upon:

RESFOIL = No. houses in each grid using fuel oil
COMDOIL = No. commercial/institutional/government employees in each grid[7]
INDDOIL = No. manufacturing employees in each grid[7]

Computer allocated emissions are tabulated in Appendices E through Q.

FUEL OIL - RESIDUAL

Area-wide Emissions

Data for total state consumption of residual fuel oil were obtained from Bureau of Mines data[12] and the methods of computation described in Reference 1 were followed.

Residential - Contact with several local fuel oil distributors indicated that there was no residential usage of residual oil in Chatham County.

Commercial-Institutional (COMROIL) - The total state consumption of residual fuel oil for the commercial-institutional sector is the combination of:

Residual type heating oils[12]	=	$2,492 \times 10^3$ bbl
Residual used by military[12]	=	100×10^3 bbl
		$2,592 \times 10^3$ bbl
Total state commercial-institutional residual oil consumption		x 42 gal/bbl
	=	$108,864 \times 10^3$ gal

Subtracting the state commercial-institutional point source usage of 620×10^3 gal/yr (Table C-1) from this total gives the commercial-institutional area source residual oil consumption of $108,244 \times 10^3$ gal/yr in the state.

The total fuel usage when apportioned to the study area by number of commercial/institutional/government employees[7,8] equals;

Total county commercial-institutional area source residual oil consumption (1973) $= (108{,}244 \times 10^3)\left(\frac{41{,}957}{985{,}800}\right)$

$= 4{,}607 \times 10^3$ gal/yr

Industrial (INDROIL) - The state industrial residual oil consumption is a combination of:

State industrial residual oil sales[12]	$= 7{,}114 \times 10^3$ bbl
State oil company sales[12]	$= 152 \times 10^3$ bbl
	$7{,}266 \times 10^3$ bbl
Total state industrial residual oil usage (1973)	$\times$ 42 gal/bbl $= 305{,}172 \times 10^3$ gal/yr

Subtracting the state industrial point source usage of $324{,}786 \times 10^3$ gal/yr (Table C-1) from this amount gives a state area source residual oil consumption of (-) $19{,}614 \times 10^3$ gal. Therefore, it is concluded that there is no industrial area source combustion of residual oil in Chatham County.

The total area source residual oil consumption for the study area is the commercial-institutional total - $4{,}607 \times 10^3$ gal/yr.

Emission factors were determined from AP-42 as in preceeding sections (Table A-1).

The area source pollutant emissions resulting from combustion of residual oil are:

Source category	Total emissions - 1973, ton/yr				
	Partic.	SO_x	CO	HC	NO_x
COMROIL	53.0	688.5	9.2	6.9	138.2

Projections

As with distillate fuel oil, projections for future residual oil usage in the commercial-institutional sector were derived from the BEA data.[11] Growth factors were determined from categories listed as wholesale and retail trade, services, and government and are shown below with projected fuel usage for each study year. Corresponding projected emissions are presented in Tables 2-2 to 2-4.

Year	1973	1975	1980	1985
Savannah AQCR earnings for wholesale & retail trade, services, and government categories (10^3 1967 $).	(interpolated) 646,984	694,100	837,200	1,012,800
Growth factor	base	1.07	1.29	1.57
COMROIL usage (10^3 gal/yr)	4,607	4,929	5,943	7,233

Subarea Distribution

Allocation of total emissions mirrored the methodology applied for the COMDOIL category. Grid emissions are tabulated in Appendices E through Q.

NATURAL GAS

Area-Wide Emissions

The consumption of natural gas in the study area would generally be best determined by contact with the natural gas distributor. Savannah Gas Co. is owned by Atlanta Gas Light which does not compute gas sales on a per county basis, but reflects distribution to their entire sales district. Numerous problems were encountered with acquiring specific data from Atlanta Gas Light. Therefore, another method used to determine the natural gas usage involved using the procedure outlined in Reference 1 with the following data:

Residential (RESNGAS) -

Total county dwelling units using natural gas[2,3] = 38,442 in 1973 (Table B-1)

Total state dwelling units using natural gas, by exponential extrapolation (r = +4.16%/yr) = $533,435\ (1960)^2/808,597(1970)^3$ (Table B-1)

= 916,007 in 1973

Total state residential natural gas consumption[13] = $86,191 \times 10^6 ft^3$

The total residential natural gas consumption in the study area is obtained by apportioning the total state consumption by the number of dwelling units using natural gas.

Total county residential natural gas consumption = $(86,191 \times 10^6)\ (\frac{38,442}{916,077})$

= $\underline{3,617 \times 10^6 ft^3/yr}$

An alternate computation to arrive at residential consump-

tion involved employing the degree-day method as in preceeding sections:

County	Dwelling units using N. gas	×	Heating requirement factor[a]	×	Degree days per year	×	$\frac{\text{Rooms}}{\text{D.U.}}\frac{1}{5}$	=	N. gas usage (10^6 ft^3/yr)
Chatham	38,442		22.5		1,597		$\frac{5.0}{5.0}$		1,381
References	2,3		1		4		2		

[a] (Ft^3 N. gas/dwelling unit-degree day)

The total residential natural gas consumption computed by this method is 1,381 x 10^6 ft^3/yr, 38 percent of the value computed using state data. Though inaccuracies are inherent with both methods of computation, it was decided to use the BOM calculation (3,617 x 10^6 ft^3/yr) for further analysis.

Commercial-Institutional (COMNGAS) - To obtain commercial-institutional fuel consumption in 1973;

State commercial sales[13] = 43,663 x 10^6 ft^3

State "other consumers"[13] = 3,590 x 10^6 ft^3

Total state commercial-institutional natural gas consumption = 47,253 x 10^6ft^3/yr

Subtracting the state commercial-institutional point source usage[6] of 3,052 x 10^6 ft^3 (Table C-1), the state area source commercial-institutional consumption is equal to 44,201 x 10^6 ft^3 per year.

Apportioning to the study area by number of commercial/institutional/government employees;[7,8]

Total county commercial-institutional area source natural gas consumption $= (44,201 \times 10^6)(\frac{41,957}{985,800})$

$= \underline{1,881 \times 10^6 ft^3/yr}$

Industrial (INDNGAS) - The industrial consumption of natural gas was computed by apportioning the state total industrial usage[13] of $174,135 \times 10^6$ ft^3 by the number of manufacturing employees.[7,9] Subtracting the state industrial point source usage[6] of $70,288 \times 10^6$ ft^3 per year (Table C-1) from this amount gives an area source natural gas consumption of $103,847 \times 10^6$ ft^3 per year in the state.
Then, consumption in the county is,

Total industrial area source natural gas consumption $= (103,847 \times 10^6)(\frac{16,875}{475,121})$

$= \underline{3,688 \times 10^6 ft^3/yr}$

The total area source consumption of natural gas in 1973 in the study area is then:

Residential	$3,617 \times 10^6 ft^3/yr$
Commercial-Institutional	$1,881 \times 10^6 ft^3/yr$
Industrial	$3,688 \times 10^6 ft^3/yr$
Total	$9,186 \times 10^6 ft^3/yr$

Emission factors input to the area 2 program with the above fuel totals were from AP-42 and are summarized in Table A-1. The total area source pollutant emissions resulting from the combustion of natural gas follow:

Source category	Total emissions - 1973, ton/yr				
	Partic	SO_x	CO	HC	NO_x
RESNGAS	18.1	1.1	36.2	14.5	144.7
COMNGAS	9.4	0.6	18.8	7.5	112.9
INDNGAS	18.4	1.1	31.3	5.5	322.7
Totals	45.9	2.8	86.3	27.5	580.3

Projections

According to Altanta Gas Light the total quantity of gas received from their pipeline suppliers has remained constant since 1969 at approximately 2.5×10^9 therms/year. Brown's Directory of North American Gas Companies estimated 2.3×10^9 therms sold in 1973. During this period, the total number of customers increased from 603,000 to 671,000. This increase was possible due to supplemental measures employed to increase reserve supplies enabling peak demand to be satisfied on winter days without increasing the total contracted supply. Though the total supply is expected to remain fixed for at least the foreseeable future, Atlanta Gas Light has been able to serve additional residential users and estimates that this trend will continue. This is possible because of decreased gas supplies made available to commercial and industrial customers. At present and for the foreseeable future, no new customer hookups in the industrial or commercial point source categories are being accepted, and present supplies to these customers are being cutback, thus allowing the increase in residential usage to continue.

Therefore, projections of natural gas consumption to 1985 were made assuming area source commercial-institutional and

industrial usage remained level at the 1973 usage rates of 1,881 x $10^6 ft^3/yr$ and 3,688 x $10^6 ft^3/yr$ respectively. Residential consumption was based on the estimated number of dwelling units using natural gas for heating purposes (Table B-1). To arrive at these figures, consideration was given to the gas market supply analysis provided by Atlanta Gas Light and engineering judgements of PEDCo-Environmental. Thus, the residential usage growth rate through 1985 was quantified to equal one third that of the 1960-1970 period, with the level gas supply situation indicating that electric power will become predominate.

The growth factors and resulting fuel usages for each study year are shown below.

Year	1973	1975	1980	1985
Number dwelling units using natural gas	38,442	39,517	42,341	45,365
Growth factor	base	1.03	1.10	1.18
RESNGAS consumption ($10^6 ft^3/yr$)	3,617	3,726	3,979	4,268

Pollutant emissions from RESNGAS combustion in future years are presented in Tables 2-2 to 2-4, assuming that the 1973 emission factors apply to all study years.

Subarea Distribution

Emissions resulting from natural gas combustion in the study area were distributed separately by subcategory. Residential emissions from natural gas usage were distributed to all grids based upon the number of dwelling units using natural gas in each grid for each study year (Table B-1).

Emissions from the commercial-institutional sector were distributed in proportion to the commercial-institutional employment in each grid. Likewise, emissions resulting from natural gas combustion by the industrial category were distributed in proportion to the manufacturing employment in each grid.[7] Appendices E through Q detail these apportioned emissions.

LPG

Area-wide Emissions

LPG fuel consumption in the study area was determined by following the method outlined in Reference 1, using the state data from Reference 14.

Total state commercial and residential LPG and ethane gas consumption = $203,658 \times 10^3$ gal/yr

Applying the natural gas ratio to approximate the residential/commercial usage breakdown:

$$\text{Natural gas ratio} = \frac{\text{state residential natural gas usage}}{\text{state commercial natural gas usage}}$$

$$= \frac{86,191 \times 10^6 \text{ft}^3}{47,253 \times 10^6 \text{ft}^3} = 1.82$$

Therefore, the total state residential usage equals $131,439 \times 10^3$ gal/yr and the commercial-institutional area source usage - $72,212 \times 10^3$ gal/yr ($72,219 \times 10^3$ gal less state commercial-institutional point source usage[6] of 7×10^3 gal- Table C-1).

Residential (RESLPG) - The county residential LPG usage, when apportioned from state totals by dwelling units using LPG[2,3] (Table B-1) equals:

$$\text{Residential LPG usage} = (131,439 \times 10^3)\left(\frac{5,956}{315,019}\right)$$

$$= \underline{2,485 \times 10^3 \text{ gal/yr}}$$

Commercial-Institutional (COMLPG) - The county commercial-institutional LPG usage, when apportioned from state totals by number of commercial-institutional employees equals:

Commercial-institutional LPG usage = $(72,212 \times 10^3)(\frac{41,957}{985,800})$

= $3,073 \times 10^3$ gal/yr

Industrial (INDLPG) - Industrial LPG usage was computed as follows:

Total state industrial LPG and ethane sales in 1973[14] = $9,860 \times 10^3$ gal

Less, state industrial LPG point source usage[6] = (-) $1,302 \times 10^3$ gal (Table C-1)

Total state industrial LPG and ethane area source usage = $8,558 \times 10^3$ gal

Apportioning by the manufacturing employee ratio (study area : state):

Total county industrial LPG and ethane area source consumption = $(8,558 \times 10^3)(\frac{16,875}{475,121})$

= 304×10^3 gal/yr

The total area source consumption of LPG in the study area is:

Residential	$2,485 \times 10^3$ gal/yr
Commercial-institutional	$3,073 \times 10^3$ gal/yr
Industrial	304×10^3 gal/yr
Total	$5,862 \times 10^3$ gal/yr

As before, emission factors applied to the above LPG consumption to calculate pollutant emissions are documented in Table A-1. The emissions from these 3 categories are:

Source category	Emissions - 1973, ton/yr				
	Partic	SO_x	CO	HC	NO_x
RESLPG	2.3	0	2.4	0.9	9.3
COMLPG	2.8	0	3.1	1.2	17.7
INDLPG	0.3	0	0.2	0	1.8
Totals	5.4	0	5.7	2.1	28.8

Projections

Trends on the projected usage of LPG are quite difficult to determine. One assumption, since LPG is primarily a residential and commercial fuel, is that it will maintain its share of the market and increase proportionately with the population. However, because LPG is currently more expensive than alternative fuels for home heating, it could be assumed that there will be no increase in its usage.

It has been established in the preceeding section that natural gas will be unavailable for new commercial/industrial users in the future. In addition, estimates by the Metropolitan Planning Commission are that the greatest centers of future development will be in the current rural fringe areas surrounding Savannah, areas most probably best suited for usage of heating fuels such as LPG and fuel oil. Due to these considerations, the former assumption was used in projecting LPG usage for 1975, 1980, and 1985. Additional considerations were that the rate of change in number of dwelling units employing LPG for heating in future years was allowed to remain consistent with the 1960-1970 trend (Table B-1). Commercial and industrial usage growth factors were, as in preceeding sections, based on BEA economic growth projections for the Savannah AQCR.

Year	1973	1975	1980	1985
No. houses using LPG	5,956	6,655	8,784	11,593
Growth factor	base	1.12	1.48	1.95
RESLPG consumption (10^3 gal/yr)	2,485	2,783	3,678	4,846
Savannah AQCR earnings for wholesale & retail trade, services and government categories	interpolated			
(10^3 1967 $)	646,984	694,100	837,200	1,012,800
Growth factor	base	1.07	1.29	1.57
COMLPG consumption (10^3 gal/yr)	3,073	3,288	3,964	4,825
Savannah AQCR mfg. earnings	interpolated			
(10^3 1967 $)	197,063	215,600	274,800	330,300
Growth factor	base	1.09	1.39	1.68
INDLPG consumption (10^3 gal/yr)	304	331	423	511

Projected emissions for these 3 categories are presented in Tables 2-2 to 2-4.

Subarea Distribution

Computer calculated emissions from the RESLPG, COMLPG, and INDLPG subcategories were allocated to grid calls proportional to their dwelling unit LPG users, commercial/institutional/government employment, and manufacturing employment, respectively.*

*Apportioning factors can be found in Tables Q-1 to Q-4.

WOOD

Area-wide Emissions

Residential wood combustion was calculated according to the degree-day method previously detailed.

County	Dwelling units using wood	x	Heating requirement factor[a]	x	Degree days per year	x	Rooms / D.U.	1/5	=	Wood usage (ton/yr)
Chatham	385		0.0017		1,597		5.0/5.0			1,045
References	2,3		1		4		2			

[a] (Ton wood/dwelling unit - degree day).

Commercial-Institutional and Industrial - There were no data available to indicate the use of wood fuel by commercial-institutional area sources. It is expected to be quite minimal. Wood burning by industrial sources is done as wood waste burning by the wood industry and included in the point source inventory. Therefore, commercial-institutional and industrial area source emissions from wood combustion are considered to be negligible.

The emission factors applied to the residential wood fuel total to calculate emissions are included in Table A-1. Pollutant emissions in Chatham county are:

Source category	Total emissions - 1973, ton/yr				
	Partic	SO_x	CO	HC	NO_x
Wood	8.9	0.0	26.1	2.1	1.0

Projections

Wood used as home heating fuel is definitely declining, especially in the urban area. This is due to home heating conversions and the renovating of older neighborhoods for various urban projects. Therefore, projections of future residential wood usage were based on the 1960-1970 rate of decrease in number of dwelling units using wood, an exponential rate as previously decribed (Table B-1).

Year	1973	1975	1980	1985
No. houses using wood	385	245	79	25
Growth factor	base	0.64	0.21	0.06
Wood usage (ton/yr)	1,045	669	219	63

Future pollutant emissions from wood combustion are presented in Tables 2-2 to 2-4.

Subarea Distribution

Allocation of emissions from wood combustion to grid cells was per the number of houses in each grid cell using wood as a heating fuel. Grid emissions for all study years are tabulated in Appendices E through Q.

5. MOBILE SOURCES

GASOLINE HIGHWAY MOTOR VEHICLES (GASMVEH)

Area-wide Emissions

This category is broken down into 2 subcategories; gasoline powered automobiles and small trucks (LDMV) and gasoline powered heavy-duty trucks (HDMV). Several methods were employed to determine the vehicle miles traveled (VMT) by these vehciles in the study area.

1. From Highway Statistics, the total measured VMT in Georgia in 1973 was $25,077 \times 10^6$ VMT. This figure encompasses all modes of driving by all types of vehicles on all road surfaces - interstate, primary, secondary, and local roads - both rural and urban.

Apportioning by the number of motor vehicle registrations:

Total vehicles registered in Ga. state (1973)[15] = 3,261,345

Total vehicles registered in study area (1973)[15] = 107,791

Total VMT travelled in Chatham County (1973)

$$= \left(\frac{107,791}{3,261,345}\right)(25,077 \times 10^6)$$

$$= \underline{829 \times 10^6 \text{ VMT/yr}}$$

The total number of registered automobiles and small trucks in the county is 92,811. Therefore, the total VMT attributable to this light duty motor vehicle (LDMV) category equals:

Total LDMV VMT traveled in study area (1973) = $\left(\frac{92,811}{107,791}\right)(829 \times 10^6)$

= $\underline{714 \times 10^6 \text{ VMT}}$

2. The second method involved breaking down the fuel sales totals obtained from the State Department of Revenue*.

Total motor fuel sales (includes on-highway and off-highway usage) in study area (1973)	=	$106,064 \times 10^3$ gal/yr
Less; off-highway fuels consumed (OFHIVEH section)	=(-)	$\underline{5,884 \times 10^3 \text{ gal/yr}}$
Equals; total on-highway gas and diesel fuel sales in study area (1973)	=	$100,180 \times 10^3$ gal/yr

From Reference 12, the total on-highway diesel fuel sales in Georgia in 1973 were: [$7,646 \times 10^3$ bbl x 42 gal/bbl = $321,132 \times 10^3$ gal/yr].

Apportioning this total to the county by the number of registered trucks and buses,[15] and assuming the percentage in the state that are diesel powered equals that in the study area:

Total trucks and buses registered in state (1973)	=	642,790
Toal trucks and buses registered in study area (1973)	=	14,980

* Personal Communication: Mr. Chan Koch, Georgia State Department of Revenue, and Mr. Edwin Pfetzing, PEDCo-Environmental Specialists, Inc., April 3, 1975.

Total diesel fuel consumed in study area (1973) $= \left(\frac{14,980}{642,790}\right)(321,132 \times 10^3)$

$= \underline{7,484 \times 10^3 \text{ gal/yr}}$

Therefore, the total on-highway gasoline consumption in the study area in 1973 equals:

$$\begin{array}{r} 100,180 \times 10^3 \text{ gal/yr} \\ (-)\ \underline{7,484 \times 10^3 \text{ gal/yr}} \\ = \quad 92,696 \times 10^3 \text{ gal/yr} \end{array}$$

If 11%[1] of the total VMT is assumed to have been consumed by heavy duty gasoline powered trucks and LDMV's get 13.6[1] mi/gal and HDMV's 8.4 mi/gal,[1] then the following describes the fuel apportionment for GASMVEH:

$$(13.6 \text{ mi/gal})(\text{gal/yr})_{LDMV} = (0.89 \text{ VMT})_{Total} \text{ and}$$

$$(8.4 \text{ mi/gal})(\text{gal/yr})_{HDMV} = (0.11 \text{ VMT})_{Total}$$

and,

$$(\text{gal/yr})_{LDMV} = [(\text{gal/yr})_{Total} - (\text{gal/yr})_{HDMV}] =$$

$$[(92,696 \times 10^3 \text{ gal/yr}) - (\text{gal/yr})_{HDMV}]$$

then,

$$\frac{(13.6)[(92,696 \times 10^3) - (\text{gal/yr})_{HDMV}]}{0.89} = \frac{(8.4)(\text{gal/yr})_{HDMV}}{0.11}$$

The equation reduces to: $1,416 \times 10^6 - 15.28\ (\text{gal/yr})_{HDMV}$

$$= 76.36\ (\text{gal/yr})_{HDMV}$$

and,

$$(\text{gal/yr})_{HCMV} = \underline{15,450 \times 10^3 \text{ gal/yr}}$$

$$(\text{gal/yr})_{LDMV} = 92,696 \times 10^3 - 15,450 \times 10^3 = \underline{77,246 \times 10^3 \text{gal/yr}}$$

Then, the total VMT (less diesel) for 1973 in the study area is 1,181 x 10^6 VMT and is computed as:

LDMV VMT = 77,246 x 10^3 gal/yr x 13.6 mi/gal =

= 1,051 x 10^6 VMT

HDMV VMT = 15,450 x 10^3 gal/yr x 8.4 mi/gal =

130 x 10^6 VMT

3. Since the State Department of Transportation traffic survey data is derived from traffic count measurements, it is assumed more accurate and was, therefore, used as the basis for emission computations. From the 1973 measured traffic counts and computed VMT data* the following summary was compiled for Chatham County:

Table 5-1. TRAFFIC COUNT DATA - 1973

County	Traffic type	Measured daily VMT	% total
Chatham	Rural	710,488	30.4
	Urban-Savannah	1,628,851	69.6
Total	All types	2,339,339	-

The total measured annual VMT would then equal;

2,339,339 x 365 = 854 x 10^6 VMT/yr

* Personal Communication: Mr. W. Glenn Scarborough, Georgia State Department of Transportation, Atlanta Area Planning, and Mr. Edwin Pfetzing, PEDCo-Environmental Specialists, Inc., April 3, 1975.

Adding 20%* for non-measured urban streets	854×10^6 VMT/yr (+)171×10^6 VMT/yr
Annual total VMT (all vehicle types) in study area - 1973	= $1{,}025 \times 10^6$ VMT/yr

The percentage of the above total attributable to truck traffic was determined from the urban/rural traffic counts which included specific counts of truck traffic. These samples did not differentiate between diesel and gasoline powered trucks. An overall weighted average of the county truck traffic percentage was computed for the rural and urban sectors.

$$\bar{X}_{trucks} = \sum_{i=n-1}^{n} \frac{[\%\text{ trucks measured in each urban/rural sample count}]_i \; [\text{Total VMT measured in each urban/rural sample count}]_i}{[\text{Total VMT measured in all urban/rural sample counts}]}$$

where, n = 2

Thus, the overall weighted average of the county rural and urban truck traffic percentage equals 14.7%.

Therefore, the total VMT breaks down to:

Total LDMV VMT in 1973 = $(1{,}025 \times 10^6)(0.853)$

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* The difference between measured VMT (854×10^6) and VMT from all categories as computed by fuel sales reports (LDMV = $1{,}051 \times 10^6$; HDMV = 130×10^6 VMT; and, Diesel = $7{,}484 \times 10^3$ gal/yr x 5.1 mi/gal = 38×10^6 VMT; Grand Total = $1{,}219 \times 10^6$ VMT) is approximately 30%. Applying two-thirds this factor allows for the portion of suburban traffic not accounted for by traffic count surveys.

$$= \underline{874 \times 10^6 \text{ VMT/yr}}$$

Total HDMV VMT (gas & diesel) in 1973 =

$$(1{,}025 \times 10^6)(0.147) = \underline{151 \times 10^6 \text{ VMT/yr}}.$$

Considering the inaccuracy of the average vehicle mileage factors used in Method 2, reasonably good agreement was found between the LDMV VMT computed from traffic count data and the LDMV VMT computed from the state gasoline sales (874×10^6 vs. $1{,}051 \times 10^6$).

Further, if 80% of the total HDMV (gas & diesel) traffic is assumed to be gasoline and 20% diesel*, then:

Total HDMV (gasoline) VMT in 1973 = $(151 \times 10^6)(.8)$

$$\underline{121 \times 10^6 \text{ VMT/yr}}$$

Total HDMV (diesel) VMT in 1973 = $(151 \times 10^6)(.2)$

$$= \underline{30 \times 10^6 \text{ VMT/yr}}$$

Due to source category input limitations imposed by the area 2 program (maximum capability = 25), the HDMV (gasoline) VMT was included with the LDMV VMT to yield total VMT attributable to gasoline motor vehicles in the study area in 1973 - ($874 \times 10^6 + 121 \times 10^6 = \underline{995 \times 10^6 \text{ VMT/yr}}$).

Emission factors for use with this category were derived from AP-42, Supplement 5, April 1975, incorporating the latest revisions and application of Federal Test Procedure data for EF calculations. The new methodology employed will not be discussed as the procedural changes are too numerous and the calculations too involved for inclusion herein (the reader is referred to Supplement 5, which should be readily

* Engineering judgment of PEDCo-Environmental Specialists, Inc.

available). In order to account for the combination of LDMV (gasoline) and HDMV (gasoline) VMT, weighted emission factors were computed. The assumptions used in computing the emission factors for each category will be listed and a brief explanation offered for each pollutant EF calculation.

LDMV - The emission factor for particulates is composed of the following components:

exhaust	0.34 gm/mi
tire wear	0.20 gm/mi
brake wear	0.02 gm/mi
Particulate emission factor for light duty motor vehicles =	0.56 gm/mi

The factors for emissions and tire wear are published figures from AP-42. The brake wear factor is unpublished but based upon 2 lb worn off per set of brake shoes each 45,000 miles. (Ref. 31)

Street dust is often-times a significant factor in total particulate emissions from vehicle travel. An attempt to quantify this component is presented in Chapter 7, where dust from paved streets has been treated as a separate fugitive dust category.

The above EF for particulates and that for SO_x (0.13 gm/mi) are assumed to remain constant through 1985.

The crux of the new procedures involves calculation of composite emission factors for each calender year under consideration for CO, HC, and NO_x. The assumptions made[10] follow:

a. Typical urban patterns of vehicle operation apply,

b. Average route speed equals 19.6 mph,

c. 20% cold engine operation,

d. Ambient temperature[16] = 65.3°F,

e. Nationwide statistics for vehicle mix apply,

f. The hot start-up phase for catalyst controlled vehicles is 27% of the operating time,

g. Vehicles are catalyst controlled from 1975-1977.

Then, the composite emission factors are calculated by:

$$e_{npstw} = \sum_{i=n-12}^{n} c_{ipn}\, m_{in}\, v_{ips}\, z_{ipt}\, r_{iptw},$$

where, n=13 (practical recognized vehicle service life).

Year	Composite emission factors - LDMV, gm/mi				
	Partic	SO_x	CO	HC	NO_x
1973	0.56	0.13	72.0	9.9	4.3
1975	0.56	0.13	61.0	8.4	4.2
1980	0.56	0.13	28.0	4.8	2.7
1985	0.56	0.13	9.7	2.0	1.1

HDMV(gasoline) - The emission factor for particulates is composed of the following components:

exhaust	0.91 gm/mi
tire wear	0.30 gm/mi
brake wear	0.03 gm/mi
Particulate emission factor for HDMV (gasoline) vehicles =	1.24 gm/mi

The factors for emissions and tire wear are published figures from AP-42. The brake wear factor is unpublished,

but based upon 3 lb worn off per set of brake shoes per 45,000 miles (Ref. 31). Again, street dust is a factor in vehicle traffic and a rough quantification of this component is shown in Chapter 7.

The emission factor for SO_x is 0.36 gm/mi. Both these factors are projected (AP-42) to remain constant through 1985.

The calculation of the composite emission factors for CO, HC, and NO_x for HDMV (gasoline) and the assumptions made follow:

a. Vehicle operation is in entirely warmed up condition.
b. The vehicle mix is based on nationwide statistics.
c. Average route speed equals 18 mph.
d. The speed correction factor is based on LDMV data.
e. There exists an average of 6 tires per vehicle.

Then, the composite emission factors are calculated by:

$$e_{nps} = \sum_{i=n-12}^{n} c_{ipn} m_{in} v_{ips}.$$

where, n=13 (practical recognized vehicle service life).

They are as follows:

Composite emission factors - HDMV, gm/mi

Year	Part.	SO_x	CO	HC	NO_x
1973	1.24	0.36	217.36	34.62	9.20
1975	1.24	0.36	204.90	30.20	10.20
1980	1.24	0.36	181.32	20.14	11.42
1985	1.24	0.36	138.90	12.23	12.32

The weighted emission factors incorporating those of both subcategories were computed as follows (an example computation for particulate emissions in 1973 is given for clarification):

$$\overline{EF}\ (\text{Partic}) = \frac{(874)(0.56) + (121)(1.24)}{(874 + 121)} = \underline{0.64\ \text{gm/mi}}$$

The following summarizes the weighted EF's computed:

Year	Composite emission factors - LDMV/HDMV, gm/mi				
	Partic	SO_x	CO	HC	NO_x
1973	0.64	0.16	89.70	12.90	4.90
1975	0.64	0.16	78.50	11.10	4.90
1980	0.64	0.16	46.60	6.70	3.80
1985	0.64	0.16	25.40	3.20	2.50

The above EF's were input with the total VMT for LDMV and HDMV (gasoline) vehicles in the study area in 1973 (995 x 10^6 VMT/yr) to the Area 2 program to calculate total and apportioned emissions. Prior to this, however, the EF's were converted to lb/10^6 VMT to ensure compatability with the fuel total units (Table A-1). The resultant total emissions are:

Source category	Total emissions - 1973, ton/yr				
	Partic	SO_x	CO	HC	NO_x
GASMVEH	702.0	175.1	98,294.5	14,136.0	5,369.5

Projections

Emission factor development for succeeding study years has already been treated. Projections of annual VMT for gasoline motor vehicles are derived from data acquired from the

Ga. State DOT.* Estimated VMT projection factors, based on data pertaining to vehicle registrations, annual vehicle-miles, population and licensed driver distributions, and roads in service were obtained. Using these growth factors and assuming that the same ratio of rural to urban VMT and the same ratio of LDMV VMT and HDMV VMT to Total VMT will prevail through 1985, the projections are:

Year	1973	1975	1980	1985
VMT Growth Factor	base	1.08	1.27	1.37
GASMVEH VMT(10^6VMT/yr)	995	1,075	1,264	1,363
Total VMT (10^6 VMT/yr)	1,025	1,107	1,302	1,404

Projecting vehicular travel at this time, given the following uncertain trends:

a. federal motor vehicle control programs,
b. average new vehicle gas mileage,
c. federal regulations governing gasoline lead content,
d. number of people buying new cars,

is a matter to be approached with extreme caution. All aspects of the current energy market must be brought to bear. Although the above issues all generally suggest declining VMT in the future, other considerations and trends suggest that because of increases in population and probable increases in fuel economy in future motor vehicles, some upward trend in VMT could be expected over the next ten years. The major point to be impressed here is that, although the VMT projection factors probably represent the

* Personal Communication: Mr. Madden, Georgia Department of Transportation, Urban Planning, and Mr. N.S. Walsh, PEDCo—Environmental Specialists, Inc., September 5, 1975.

best available estimates, they should not be regarded as absolute inviolate prophecies of future activity.

Subarea Distribution

Allocation of emissions from all motor vehicle sources was based upon the distribution of total measured VMT by functional classification (rural, urban) in each grid cell as determined from traffic count maps. This total was, of course, composed of gasoline motor vehicles and diesel motor vehicles (truck) traffic. Using the truck traffic percentage factor as previously described, the total was broken into GASMVEH VMT/grid and DIEMVEH VMT/ grid (grid apportioning factors). Apportioning factors for future years were projected using the growth factors outlined above.

DIESEL HIGHWAY MOTOR VEHICLES (DIEMVEH)

Area-wide Emissions

This category includes buses and heavy duty trucks using diesel fuel. Since measured VMT data was used to determine the emissions from gasoline motor vehicles, the same VMT data was also used for this category. However, to maintain consistency, all three methods of fuel totals computations are presented for comparison.

1. From the previous section - Method 1, the total study area VMT in 1973 was calculated as 829×10^6 VMT. Subtracting the VMT attributable to LDMV's, the diesel truck VMT can be calculated:

Total HDMV (gas & diesel) VMT in study area $= (829 \times 10^6) - (714 \times 10^6)$

$= 115 \times 10^6$ VMT/yr.

Further, if gasoline powered trucks and buses account for 80 percent of the total and diesel powered - 20 percent, then:

HDMV (gasoline) $= (115 \times 10^6)(.8) = 92 \times 10^6$ VMT/yr

DIEMVEH (diesel) $= (115 \times 10^6)(.2) = 23 \times 10^6$ VMT/yr

2. From the previous section - Method 2, considering the State Department of Revenue Fuel Sales Reports, the total diesel fuel sold in the study area in 1973 was $7,484 \times 10^3$ gal/yr. Applying an average vehicle mileage factor of 5.1 mpg[1] to this figure:

Total DIEMVEH VMT in study area in 1973 $= (7,484 \times 10^3$ gal/yr$)(5.1$ mi/gal$)$

$= 38 \times 10^6$ VMT/yr

3. The annual VMT attributable to diesel traffic as computed from county traffic count data was calculated in the previous section - Method 3, as 30×10^6 VMT/yr, assuming the same 80%/20% - gas/diesel truck breakdown as above. It is seen that all 3 methods of computation produce values reasonably close in magnitude.

Emission factors applied to this category were determined from AP-42, Supplement 5, April 1975, in the same fashion as were those for gasoline motor vehicles. Assumptions appropriate to the calculations made will be listed here, also.

The emission factor for particulates is composed of the following components:

exhaust	1.3 gm/mi
tire wear	0.50 gm/mi
brake wear	0.03 gm/mi

Emission factor for heavy duty diesel powered motor vehicles = 1.83 gm/mi

The factors for emissions and tire wear are published figures from AP-42. The brake wear factor is unpublished, but based upon 3 lb worn off per set of brake shoes per 45,000 miles. Again, street dust is a factor in vehicle traffic and a rough quantification of this component is shown in Chapter 7.

The EF for SO_x is 2.8 gm/mi and it, along with that for particulates, remains constant through 1985 (Tables A-2, A-3, A-4).

The assumptions made for calculation of the composite emission factors for CO, HC, and NO_x are:

a. Average route speed equals 45 mph,
b. All engine operation is in warmed up condition
c. Vehicle mix is based upon nationwide statistics
d. There exists an average of 10 tires per vehicle

Then, the composite emission factors are calculated by:

$e_{nps} = \sum_{i=n-12}^{n} c_{ipn} m_{in} v_{ips}$, and the resultants shown below:

Year	Composite emission factors - DIEMVEH, gm/mi				
	Particulate	SO_x	CO	HC	NO_x
1973	1.83	2.8	8.6	2.3	25.1
1975	1.83	2.8	8.6	2.3	25.1
1980	1.83	2.8	8.6	2.3	24.2
1985	1.83	2.8	8.6	2.3	25.2

After converting the emission factors to a $lb/10^6$ VMT basis, they were input, with the DIEMVEH VMT total, to the Area 2 Program for total and apportioned emissions calculations. The EF's in appropriate input form are presented in Table A-1. The resultant emissions for 1973 are:

Source category	Total emissions - 1973, ton/yr				
	Particulate	SO_x	CO	HC	NO_x
DIEMVEH	60.5	92.5	284.1	76.0	829.3

Projections

Projections of future VMT for diesel motor vehicles were developed identically to those for gasoline motor vehicles.

The growth factors provided by the GA. State DOT pertaining to the county total VMT projections were assumed to apply to travel by this category also.

Again, the same vehicle mix and ratio of DIEMVEH VMT/Total VMT were assumed to apply through 1985. These projections should be viewed with the same astute awareness as those for gasoline motor vehicles.

Year	1973	1975	1980	1985
VMT Growth Factor	base	1.08	1.27	1.39
Total VMT (10^6 VMT/yr)	1,025	1,107	1,302	1,404
DIEMVEH VMT (10^6 VMT/yr)	30	32	38	41

Subarea Distribution

Allocation of emissions from this category was performed exactly as that for gasoline motor vehicles. They are tabulated in Appendices E through Q.

AIRCRAFT

Area-Wide Emissions

Chatham County's existing civil airport system is comprised of one public airport (Savannah Municipal), a private general aviation facility (Hopeton Plantation), and three seldom used private heliports. Previously in the airport system, Saffold Field is now the site of a proposed residential-commercial development and Rollins Heliport is now closed. The vast majority of military traffic at Savannah Municipal Airport is connected with short term active duty training periods for Reserve and Air National Guard Squadrons.[17] Hunter Army Airfield, the only military field in the county, conducts operations consisting mainly of helicopter traffic. It is expected that this facility will remain in the military inventory and will not become available for civil use in the forseeable future.

Data presented in Tables 5-2 and 5-3 were used in computing the emissions by airport (Table 5-4) from this category. Emission totals were computed by airport since allocation of emissions to grids are made on this basis.

Aircraft operations at Savannah Municipal airport, the only one with FAA operated air traffic control facilities, were obtained from Reference 17 - 1974 Chatham County Airport System Plan. Data pertaining to military operations at Hunter Army Airfield were obtained from Reference 18 - Military Air Traffic Activity Report, after repeated unsuccessful attempts to obtain more specific data from military officials. Operations activity reflected for Hopeton Plantation airport was obtained from the fixed base operator.*

* Personal communication: Mr. Joe Tomme, Hopeton Plantation Airport, and Mr. N.S. Walsh, PEDCo-Environmental, Sept. 25, 1975.

Table 5-2. LTO CYCLES BY AIRPORT

Aircraft category	Total operations	Total LTO cycles[a]	LTO cycles by airport					
			Savannah Municipal[b]	Hunter AAF[c]	Hopeton Plantation[d]	Savannah Memorial Hospital Helipad[b]	Citizens and Southern Bank Helipad[b]	St. Joseph's Hospital Helipad[b]
Air Carrier	12,414	6,207	6,207	-	-	-	-	-
B-727	(5,793)	(2,897)	(2,897)					
DC-8	(1,655)	(828)	(828)					
DC-9	(4,966)	(2,483)	(2,483)					
Air Taxi	0	0	-	-	-	-	-	-
General Aviation	70,027	35,014	31,037	2,177	1,800	-	-	-
Single engine	(51,061	(25,531)	(22,222)	(1,559)	(1,750)			
Multi-engine	(18,966)	(9,483)	(8,815)	(618)	(50)			
Military	38,125	19,063	5,089	13,974	-	-	-	-
Jet	(0)	(0)						
Transport (C-130)	(10,177)	(5,089)	(5,089)					
Helicopter	(27,948)	(13,974)		(13,974)				
Piston	(0)	(0)						
Totals	120,566	60,283	42,333	16,151	1,800	Neg.	Neg.	Neg.

[a] LTO cycles = No. reported operations/2.

[b] Reference 17.

[c] Reference 18.

[d] Personal Communication: Mr. Joe Tommee, Hopeton Plantation Airport, and Mr. N.S. Walsh, PEDCo-Environmental Specialists, Inc., September 25, 1975.

Table 5-3. ESTIMATED ANNUAL EMISSIONS BY AIRCRAFT CATEGORY

Aircraft category	Total LTO cycles	Number of engines	Emission factors, lb/eng-LTO[a]					Emissions, ton/yr				
			Particulate	SO_x	CO	HC	NO_x	Particulate	SO_x	CO	HC	NO_x
Air carrier	(6,207)	-										
B-727	2,897	3	0.41	1.01	17.0	4.9	10.2	1.8	4.4	73.8	21.3	44.3
DC-8	828	4	1.21	1.56	47.4	41.2	7.9	2.0	2.6	78.5	68.2	13.1
DC-9	2,483	2	0.41	1.01	17.0	4.9	10.2	1.0	2.5	42.2	12.2	25.3
Air taxi	(0)	-										
General aviation	(35,014)	-										
Single engine	25,531	1	0.02	0.014	12.2	0.4	0.047	0.3	0.2	155.7	5.1	0.6
Multi-engine	9,483	2	0.02	0.014	12.2	0.4	0.047	0.2	0.1	115.7	3.8	0.4
Military	(19,063)	-										
Jet	0	-										
Transport (C-130)	5,089	4	1.1	0.41	5.7	2.7	2.2	11.2	4.2	58.0	27.5	22.4
Helicopter	13,974	2	0.25	0.18	5.7	0.52	0.57	3.5	2.5	79.7	7.3	7.9
Piston	0	-										
Totals	60,283							20.0	16.5	603.6	145.4	114.0

[a] Emission factors for each class of aircraft are based on LTO cycles by mode, e.g. taxi-idle, take-off, etc.[10]

Table 5-4. AIRCRAFT EMISSIONS BY AIRPORT - 1973

Airport	Aircraft category	Emissions - 1973, ton/yr[a]				
		Particulate	SO_x	CO	HC	NO_x
Savannah Municipal (Grid 9)	Air carrier	4.8	9.5	194.5	101.7	82.7
	Air taxi	-	-	-	-	-
	G/A - S/E Piston	0.3	0.2	135.5	4.4	0.5
	- M/E Piston	0.2	0.1	107.6	3.5	0.4
	Military - transport (C-130)	11.2	4.2	58.0	27.5	22.4
	Total	16.5	14.0	495.6	137.1	106.0
Hunter AAF (Grid 38)	G/A - S/E Piston	Neg.	Neg.	9.3	0.3	Neg.
	- M/E Piston	Neg.	Neg.	7.5	0.2	Neg.
	Military - helicopter	3.5	2.5	79.7	7.3	7.9
	Total	3.5	2.5	96.5	7.8	7.9
Hopeton Plantation (Grid 30)	G/A - S/E Piston	Neg.	Neg.	10.6	0.4	Neg.
	- M/E Piston	Neg.	Neg.	0.6	Neg.	Neg.
	Total	Neg.	Neg.	11.2	0.4	Neg.
Savannah Memorial Hospital Helipad	G/A - Helicopter	Neg.	Neg.	Neg.	Neg.	Neg.
Citizen's & Southern Bank Helipad	G/A - Helicopter	Neg.	Neg.	Neg.	Neg.	Neg.
St. Joseph's Hospital Helipad	G/A - Helicopter	Neg.	Neg.	Neg.	Neg.	Neg.
Total (all airports)		20.0	16.5	603.6	145.4	114.0

[a] Includes emissions >0.1 ton/yr.

Emission factors were obtained directly from AP-42. They are based on specific aircraft or engine type where possible, in all cases reflecting the factor appropriate for the aircraft category. Several assumptions were necessary in order to classify the operational activity and select the appropriate emission factors. They are hereby listed:

- Hunter Army Airfield
  a. Assume military operations are all training type helicopter.
  b. Assume civilian operations occurring are by general aviation single engine piston driven aircraft, most probably operated by military flying clubs on base.
- Civilian Fields
  a. Assume all military operations at civilian fields are by 4 engine transport type aircraft (C-130).
  b. Assume G/A multi-engine traffic at Savannah Municipal approximates the ratio of the number of registered multi-engine aircraft in the county to the total number of registered aircraft.

Projections

Air carrier traffic, in general, has been cut back in efforts to conserve fuel and promote more efficient utilization of aircraft. Forecasts herein do not reflect any impact on activity levels which may stem from the energy crisis. However, analysis of projected air traffic activity at Savannah Municipal Airport portends significant facilities expansion programs to properly accomodate anticipated increases in operational activity of 385 percent through 1985.

This tremendous growth potential for air travel in Savannah-Chatham County is portrayed in detail in Reference 17.

Indications are that general aviation air traffic is also increasing, despite uncertainties surrounding the current energy market. Since no hard statistics were available for Hopeton Plantation Airport, projections were made based on the average estimated annual increase in general aviation activity (10%) provided by the Fixed Base Operator.*

Projections of military flying activity are extremely difficult to prepare due to cutbacks in defense budget appropriations and military-wide austerity and streamlining programs. The total amount of military flying done is dependent upon defense policies and the number of aircraft in the military inventory. Currently, Pentagon policy is to reduce active force strength and promote greater expansion, utilization and mobilization of air reserve programs. Thus, it is assumed that an increase in one will be offset by a decrease in the other and, therefore, emissions from aircraft are shown to remain level through 1985. Projected emissions by airport are presented in Table 5-5.

Subarea Distribution

Aircraft are considered area sources and the emissions from them are applied to the grids at the airport locations. For purposes of computation then, aircraft emissions were input to the Area 2 Program as "hand calculated emissions" and added to the apportioned emissions of the appropriate grid cells (Appendices E through Q).

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* Personal Communication: Mr. Joe Tomme, Hopeton Plantation Airport, and Mr. N.S. Walsh, PEDCo-Environmental, Sept. 25, 1975.

Table 5-5. GROWTH DATA AND PROJECTED EMISSIONS BY AIRPORT

Airport	Year	Total operations	Growth factor	Emissions, ton/yr				
				Particulate	SO_x	CO	HC	NO_x
Savannah Municipal[a] (Grid 9)	1973	84,664	base	16.5	14.0	495.6	137.1	106.0
	1975	133,598	1.57	25.9	22.0	778.1	215.2	166.4
	1980	250,600	2.96	48.8	41.4	1,466.9	405.8	313.8
	1985	326,200	3.85	63.5	53.9	1,908.1	527.8	408.1
Hunter AAF[b] (Grid 38)	1973	32,302	base	3.5	2.5	96.5	7.8	7.9
	1975	32,302	1.00	3.5	2.5	96.5	7.8	7.9
	1980	32,302	1.00	3.5	2.5	96.5	7.8	7.9
	1985	32,302	1.00	3.5	2.5	96.5	7.8	7.9
Hopeton Plantation[c] (Grid 30)	1973	3,600	base	Neg.	Neg.	11.2	0.4	Neg.
	1975	4,320	1.20	Neg.	Neg.	13.4	0.5	Neg.
	1980	6,120	1.70	Neg.	Neg.	19.0	0.7	Neg.
	1985	7,920	2.20	Neg.	Neg.	24.6	0.9	Neg.
Totals	1973	120,566	base	20.0	16.5	603.6	145.4	114.0
	1975	170,220	1.41	29.4	24.5	888.0	223.5	174.3
	1980	289,022	2.40	52.3	43.9	1,582.4	414.3	321.7
	1985	366,422	3.04	67.0	56.4	2,029.2	536.5	416.0

[a] Reference 17.

[b] No projected increase in activity available - engineering judgment of PEDCo-Environmental.

[c] Personal Communication: Mr. Joe Tomme, Hopeton Plantation Airport, and Mr. N.S. Walsh, PEDCo-Environmental, September 25, 1975.

RAIL LOCOMOTIVE (RAILLOC)

Area-Wide Emissions

Emissions as a result of railroad activity in Chatham county were computed from the reported state railroad fuel usage.[12]

Total state fuel oil (mainly distillate) usage by railroads (1973)* = $2{,}845 \times 10^3$ bbl x 42 gal/bbl

= $119{,}490 \times 10^3$ gal/yr

This quantity was then apportioned to the study area by railroad track mileage:

Total railroad track mileage in study area† = 294

Total state railroad track mileage[19] = 5,417

Total county fuel oil usage by railroad = $(119{,}490 \times 10^3)(\frac{294}{5417})$

= $\underline{6{,}485 \times 10^3 \text{ gal/yr}}$

Emission factors, based on average locomotive statistics[10] (Table A-1), were applied to the above fuel consumption to yield total pollutant emissions for this category of:

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
RAILLOC	81.1	184.8	421.5	304.8	1199.7

Projections

The railroad industry in general has shown a decrease in activity in the past several decades. However, at least one factor can be cited to indicate a possible growth trend in

* Assumes all fuel sold in the state, but not used in the state equals that not sold in the state, but used in the state.

† Estimated from USGS maps.

railroad activity for succeeding years, provided the recession comes to an end. Although no quantitative measure of this factor was obtained, it remains that the hauling of coal by the railroads is likely to increase as dwindling supplies of cleaner fuels place more importance on coal as a predominant energy source. However, attempts to quantify this increase would be difficult. Therefore, all other subjective indications pointed to a leveling off of fuel usage and emissions from 1975-1985. Fuel usage by railroads in 1975, 1980 and 1985 will be held at 6,485 x 10^3 gal/yr and projected emissions are as presented in Tables 2-2 to 2-4.

Subarea Distribution

The miles of railroad track in each grid were measured from USGS topographic maps of the study area. The total measured mileage was 294. This estimate included mainline track mileage and track mileage for significant yard facilities. Thus, allocating proportionately to the total measured track mileage, rather than the mainline mileage only, more heavily weights the grids containing greater railyard activity. Switch engine activity in the yards was assumed to be included in the emissions allotted to the grids with yard activity. The total emissions from this category were then distributed to each grid on the basis of track mileage contained in the grid.

VESSELS (PLSVESL/CMSEAVES)

Area-Wide Emissions

Estimation of pollutant emissions attributable to vessels in Chatham County consists of determining the contribution from two distinct categories; pleasure vessels (PLSVESL), and commercial/seaport (CMSEAVES) type or river and ocean-going vessels. To achieve greater resolution, the second category was further subdivided into those commercial vessels utilizing Savannah's harbor or port facilities and gaining entry exclusively from ocean access east of the county, and those vessels "passing through" county inland waters or ports via the intracoastal waterway. For each subcategory, the appropriate methodology and calculations supporting emissions estimation development are presented.

Pleasure Vessels (PLSVESL) - Several local agencies were contacted to determine the number of registered pleasure boats in the county. However, there appears to exist no reliable data on small boating activity.* Therefore, the 1973 state boat registration total of 200,000 boats+ was used, in accordance with procedures set forth in Reference 1, for calculating emissions.

Fuel consumption by vessel activity:

No. registered boats in state = 200,000

Inland water surface area (state)[20] = 803 mi^2

Inland water surface area (study area)++ = 100 mi^2

Fuel usage factor[1] = 160 gal/boat-year

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* Personal communication: Lillian Dean, GA DNR, Office of Planning and Research and Mr. N.S. Walsh, PEDCo, Sept. 18, 1975.

+ Personal communication: Mrs. Christine Hull, GA DNR, Boat Registration Division, and Mr. N.S. Walsh, PEDCo-Environmental, May 16, 1975.

++ Determined from USGS maps, includes all lakes/streams/waterways/estuaries greater than 1 acre in area.

Fuel consumption (state) 1973 =
(200,000 boats)(160 gal/boat-year)
= 32,000 x 10^3 gal/yr.

Fuel consumption (study area) 1973 = $(32{,}000 \times 10^3)(\frac{100}{803})$
= $\underline{3{,}985 \times 10^3 \text{ gal/yr}}$

Emission factors for input to the Area 2 Program with the above fuel total were taken directly from the outboard powered vessels section of AP-42 and are listed in Table A-1.

Emissions for 1973 then, are:

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
PLSVESL	0	12.8	6,575.3	2,191.8	13.2

Commercial/Seaport Vessels (CMSLAVES) - The Port of Savannah has been a vital factor in the stimulation of industrial growth and economic progress in the Savannah area and in the entire State of Georgia. The City of Savannah's growth and vitality have been particularly dependent upon port activities.[21] The Georgia Ports Authority operates two major terminals at Savannah, the Ocean Terminal and the Garden City Terminal. The Atlantic Intracoastal Waterway extends from north to south through the county and provides a second access to the Port of Savannah. The waterway serves both commercial and pleasure vessels.

1. Harbor (ocean access) related activity - This section considers all commercial/seaport vessels served by Savannah Harbor which have ocean access. Emissions from both underway fuel consumption and in-port fuel consumption are considered.

Underway fuel consumption:

According to Reference 22, the total number of self-propelled vessels inbound to Savannah Harbor in 1973 was 4,369. However, some duplication may exist in this number of reported vessel trips in that those American Flag vessels engaged in combined foreign and domestic commerce on the same voyage may be reported twice. Also, excluded from this figure are United States Army and Navy vessels and foreign military and Navy craft. The Savannah Harbormaster's Office reported 1,639 self-propelled ships inbound to the harbor in 1973 with 1,578 remaining in-port for an average of 2 days each.* This estimate was deemed to be more indicative of actual vessel movement. Assuming all ships entering the harbor eventually departed, total vessel movements in 1973 were 3,278. Also, the total tonnages handled by Garden City Terminal and Ocean Terminal in 1973 were 2,166,673 tons (75.9%) and 687,653 tons (24.1%), respectively.[23]

Based strictly on these tonnages handled, it is assumed that 24.1% of the vessels stop at Ocean Terminal (a distance of 15.5 mi from Ft. Pulaski - zero mile channel station), and 75.9 percent continue through to Garden City Terminal (19.3 mi from Ft. Pulaski). Therefore:

- Vessel-miles to Ocean Terminal = (3,278)(15.5) = 50,809
- Vessel-miles (Ocean Terminal to G.C. Term) = (3,278)(.759)(3.8) = 9,454

Total vessel-miles = 60,263

Assuming the steamship/motorship vessel-mile ratio is approximated by the ratio of state residual: distillate

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* Personal Communication: Mr. James Trussel, GA Ports Authority (Garden City Terminal), and Mr. N.S. Walsh, PEDCo, September 19, 1975.

fuel oil sales, fuel consumption and emission factors can be determined:

- Sales of fuel oil for vessel bunkering use (GA-1973),[12]
  - Distillate = 67,000 bbl = $2,814 \times 10^3$ gal (14.5%)
  - Residual = 396,000 bbl = $16,632 \times 10^3$ gal (85.5%)
  - Total = $19,946 \times 10^3$ gal

- Then, ship-type breakdown and fuel consumation is:
  - Steamship vessel-miles = $(60,263)(.855)(\frac{\text{N.-Mi.}}{1.15\ \text{S.Mi}})$
    = 44,804 ves.-n.mi
  - Motorship vessel-miles = $(60,263)(.145)(\frac{\text{N.-Mi}}{1.15\ \text{S.Mi}})$
    = 7,598 ves-n.mi

Emission factors and emissions are:

Vessel category	Emission factors, lb/n.-mi.					Emissions - underway, ton/yr				
	Part.	SO_x	CO	HC	NO_x	Part.	SO_x	CO	HC	NO_x
Steamships	0.4	13.2	0.002	0.2	4.6	9.0	295.7	Neg.	4.5	103.0
Motorships	2.0	1.5	1.2	0.9	1.4	7.6	5.7	4.6	3.4	5.3
Total						16.6	301.4	4.6	7.9	108.3

In-port fuel consumption:

Again, based on the relative tonnages handled by the two GPA ports, the number of vessels in-port at each in 1973 and the resulting emissions are:

- Ocean Terminal (grid 21):
  (1,578 total vessels in-port)(.241) = 380 vessels at Ocean Terminal
  - Steamships
    Ves-days in-port = (380)(.855)(2) = 649.8 ves-day/yr
    fuel used = (649.8)(1900 gal/day)[10] = 1235×10^3 gal/yr

- Motorships
  Ves-days in-port = (380)(.145)(2) =
  110.2 ves-days/yr
  fuel used = (110.2)(660 gal/day) =
  72.7 x 10^3 gal/yr

Emission factors applied to the above vessel-days totals and resulting emissions are:

Vessel category	Emission factors, lb/ves-day					Emissions - in-port, ton/yr				
	Part.	SO_x	CO	HC	NO_x	Part.	SO_x	CO	HC	NO_x
Steamships	15.4	564	0.08	9.0	200	15.4	577.1	Neg.	9.2	204.7
Motorships	16.5	43.0	46.0	33.0	50.0	2.9	7.5	8.0	5.7	8.7
Total						18.3	584.6	8.0	14.9	213.4

- Garden City Terminal (Grid 10)
  (1,578 total vessels in-port)(.759) = 1,197 vessels at Garden City Terminal
  - Steamships
    Ves-days in port = (1,197)(.855)(2) =
    2,047 ves-days/yr
    fuel used = (2,047)(1900 gal/day) =
    3,889 x 10^3 gal/yr
  - Motorships
    Ves-days in-port = (1,197)(.145)(2) =
    347 ves-days/yr
    fuel used = (347)(660 gal/day) =
    229 x 10^3 gal/yr

Emission factors and emissions again, are as above:

Vessel category	Emission factors, lb/ves-day					Emissions - in-port, ton/yr				
	Part.	SO_x	CO	HC	NO_x	Part.	SO_x	CO	HC	NO_x
Steamships	15.0	564	0.08	9.0	200	4.9	193.2	Neg.	2.9	65.0
Motorships	16.5	43.0	46.0	33.0	50.0	0.9	2.4	2.5	1.8	2.8
Total						5.8	185.6	2.5	4.7	67.8

The total emissions from harbor related shipping in 1973 are presented:

Emission source	Emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
Underway	16.6	301.4	4.6	7.9	108.3
In-port					
Ocean terminal	5.6	185.6	2.5	4.7	67.8
Garden City Terminal	18.3	584.8	8.0	14.9	213.4
Total Harbor related emissions	40.7	1,071.8	15.1	27.5	389.5

2. Intracoastal Waterway Related Activity - The only available source indicating activity on this waterway reported 10,099 total craft (75% - 8 ft. draft or less) north/south bound on the waterway in 1973.[22] The waterway extends for 42.1 mi through the county. Therefore:

- Total vessel-miles traveled = (10,099)(42.1) = 425,168 ves-mi/yr

Assuming an average mix of craft (smaller than those utilizing the seaport) that use approximately 5 gal fuel/mi at 8 mi/hr, the fuel specific emission factors in AP-42, Supplement 4, were converted to mileage specific factors:

$$\text{e.g.; } SO_x \text{ EF} = \frac{27 \text{ lb}/10^3 \text{ gal}}{10^3} \times 5 \text{ gal/mi} = 0.135 \text{ lb/mi}$$

$$SO_x \text{ emissions} = (0.135 \text{ lb/mi})(425,168) = 28.7 \text{ ton/yr}$$

The emission factors and resulting emissions are summarized:

Emission source	Emission factors, lb/mi					Emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x	Part.	SO_x	CO	HC	NO_x
Intracoastal waterway	0.13	0.135	0.5	0.25	1.4	27.6	28.7	106.3	53.1	297.6

The total emissions attributable to commercial vessels operating in Savannah Harbor or on the intracoastal waterway in 1973 are:

Emission source	Emissions, ton/yr				
	Part.	SO_x	CO	HC	NO_x
Harbor related	40.7	1,071.8	15.1	27.5	389.5
Intracoastal waterway	27.6	28.7	106.3	53.1	297.6
Total	68.3	1,100.5	121.4	80.6	687.1

Projections

Pleasure Vessels - In today's conservation intensive fuel market, predicting future fuel use trends is difficult, to say the least. Ideally, predictions for this subcategory would best be made based on estimations of future pleasure boat registrations or fuel consumption. However, these data were unavailable. Therefore, projections have been derived from population growth factors*, reducing the factors by 50 percent due to all subjective indications that fuel usage by secondary consumption sources will not increase in proportion to that for other sources.

Therefore, future estimations of fuel usage are:

Year	1973	1975	1980	1985
Total population	185,338	192,384	210,000	230,700
Growth factor	base	1.04	1.13	1.24
Adjusted growth factor	base	1.02	1.06	1.12
PLSVESL fuel usage (10^3 gal/yr)	3,985	4,065	4,224	4,463

* Source: Chatham County - Savannah Metropolitan Planning Commission.

Corresponding emissions for the study years are presented in Tables 2-1 to 2-4.

Commercial/Seaport Vessels -

1. Harbor Related Activity - There is no feasible method of projecting future port impacts. It is possible, however, to obtain a measure of future port impact on Savannah's air quality by projecting freight tonnages to be handled. Savannah's freight tonnage is estimated to have an average annual growth rate of between 3.6 percent and 4.5 percent in the 1970-1990 period.[24]

Several observations must be made here. While the net register tonnage handled by Savannah's ports has increased at an average annual rate of 6.45 percent over the period 1960-1973, the number of registered vessels in-port has decreased from 1,650 in 1960 to 1,578 in 1973, an average annual rate of 7.1 percent.[23] This trend suggests that more tonnage is being handled by fewer ships and reflects: 1) advances in containerization technology, and 2) the increasing size of ships.

A case could be made for correlating the percent increase in tonnage handled with the resulting percent decrease in number of ships in-port in the past to project the number of ships expected to use harbor facilities in future years. From this analysis, the decreasing number of ships would portend decreasing emissions. However, though the number of ships in-port will indeed be less, it is assumed that the fuel consumed per ton of cargo handled will remain constant and therefore, emissions will increase due to the ship's greater size and increased fuel consumption. For the

purposes of this report then, projected emissions are assumed directly related to projected tonnage throughput (assume average 4.5% on base year 1970).[24]

Growth factors and projected emissions from harbor-related vessel activity are:

Year	1970	1973	1975	1980	1985
Growth factors (1970 base - 4.5%/yr)	base	1.135	1.225	1.45	1.675
Growth factors (1973 base - adjusted)		base	1.08	1.28	1.48

Emission source - year		Emissions, ton/yr				
		Part.	SO_x	CO	HC	NO_x
Harbor related	1973	40.7	1,071.8	15.1	27.5	389.5
	1975	44.0	1,157.5	16.3	29.7	420.7
	1980	52.1	1,371.9	19.3	35.2	498.6
	1985	60.2	1,586.3	22.3	40.7	576.5

2. Intracoastal Waterway Related Activity - The total tonnage transported on the Atlantic Intracoastal Waterway in Georgia has remained fairly stable over recent years.[24] No data was found to enable detailed projections of vessel activity for this subcategory. Therefore, emissions were assumed to remain level to 1985.

Projected emissions for all commercial/seaport vessels are:

Emission source - year		Emissions, ton/yr				
		Part.	SO_x	CO	HC	NO_x
Comm/ seaport total	1973	68.2	1,130.5	121.4	80.7	687.0
	1975	71.5	1,186.2	122.6	82.9	718.2
	1980	79.6	1,400.6	125.6	88.4	796.1
	1985	87.7	1,615.0	128.6	93.9	874.0

Subarea Distribution

Pleasure Vessels - Pollutant emissions were allocated to grid cells in proportion to the inland water area present therein, determined from USGS maps (Appendices E through Q).

Commercial/Seaport Vessels - Emissions for both subcategories contained herein were determined for each grid cell in proportion to the vessel channel traffic mileage contained therein. For the in-port emissions, allocation was made directly to the grid containing the terminal - grid 21 for Ocean Terminal associated emissions, and grid 10 for emissions at the Garden City Terminal. In each case, emissions were added to the Area 2 Program as "additional emissions." Distribution to subarea based on square miles of usable aquatic surface area.

OFF-HIGHWAY VEHICLES (OFHIVEH)

Area-wide Emissions

This category includes off-highway vehicles using diesel and gasoline fuels. Typical gasoline fuel users are farm tractors, lawnmowers, compressors, pumps, and small electric generators. Typical diesel fuel users are farm tractors, construction equipment, emergency generator power units, and compressor engines. Of the farm tractors, approximately 60 percent are assumed to be gasoline powered.[1]

Two methods were employed to check fuel consumption by this category. For the first, state fuel totals were apportioned to the county by population:

1. a) Gasoline:

GA State Off-highway Gasoline usage (1973)[15] $= 51,552 \times 10^3$ gal/yr

Study Area Off-Highway Gasoline usage (1973)

$$= (51,552)\left(\frac{185,338}{4,786,000}\right)$$

$$= 1,996 \times 10^3 \text{ gal/yr}$$

b) Diesel Fuel:

GA. State Off-Highway Diesel Fuel usage (1973)[12]

$$= 1,284 \times 10^3 \text{ bbl/yr} \times 42 \text{ gal/bbl}$$

$$= 53,928 \times 10^3 \text{ gal/yr}$$

Study area Off-Highway Diesel Fuel Usage (1973)

$$= (53,928)\left(\frac{185,338}{4,786,000}\right)$$

$$= 2,088 \times 10^3 \text{ gal/yr}$$

Therefore, the total fuel used for off-highway purposes in 1973 is 1,996 x 10^3 gal/yr + 2,088 x 10^3 gal/yr, or 4,084 x 10^3 gal/yr.

The second method entailed applying the average fuel use factors published in Reference 1.

2. a) Gasoline:

Gasoline tractor fuel consumption rate = 1,000 gal/tractor-yr

Total tractors in study area[25] = 109*

Gasoline tractors study area = 109 (.6)+

= 65

Total tractor gasoline usage = (65)(1,000)

= 65 x 10^3 gal/yr

"Other" gasoline consumption factor[1] = 13 gal/capita/yr

"All other" gasoline usage = 13(185,338)

= 2,409 x 10^3 gal/yr

Therefore, total off-highway gasoline consumption equals 2,474 x 10^3 gal/yr, compared to 1,996 x 10^3 gal/yr, calculated by Method 1.

b) Diesel Fuel:

Diesel tractor fuel consumption rate = 1,000 gal/tractor-yr

Diesel tractors in study area = 109 (.35)+ = 38

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* 1969 data; assume same number for 1973 due to the normal expected increase being offset by counteracting trends such as decreasing farm land availability due to urban encroachment.

+ Of tractor total: 60% are gasoline powered, 35% diesel powered and 5% LPG powered.[1]

Total diesel tractor diesel fuel usage = (38)(1,000)
= 38×10^3 gal/yr

Construction equipment fuel usage rate =
5,000 gal/non-bldg. construction
employee-yr

Total non-bldg. construction employees in study area[26] = 400

Total construction equipment
diesel fuel usage = (5,000)(400)
= $2,000 \times 10^3$ gal/yr

"Other" diesel fuel usage factor[1] = 7.4 gal/capita-yr

Total "All Other" diesel fuel
usage = (7.4)(185,338)
= $1,372 \times 10^3$ gal/yr

Therefore, total off-highway diesel fuel consumption in the study area equals $3,410 \times 10^3$ gal/yr, compared to $2,088 \times 10^3$ gal/yr, computed by Method 1. Due to inaccuracies inherent with geographical apportioning techniques and the tendency of BOM state totals to be underestimated, the fuel use quantities calculated by Method 2 were used for emissions calculations. Since this whole category was to be considered as an entity, the total fuel usage for input to the Area 2 Program was: $3,410 \times 10^3$ gal/yr + $2,474 \times 10^3$ gal/yr = $5,884 \times 10^3$ gal/yr.

Emission factors applied to this category were developed as weighted averages of the factors presented in AP-42 for each

individual category. The factors, by category, obtained from AP-42 and the weighted factors derived therefrom, as input with the fuel totals to the Area 2 Program, are tabulated in Table 5-6.

Total estimated emissions for the off-highway vehicles category, including both gasoline and diesel fuel users, are as shown:

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
OFHIVEH	73.3	59.1	4,671.9	904.1	797.9

Projections

Although unobtainable, State projections of fuel consumption for this category would depict the most accurate usage. Therefore, they were based on population growth projections employing just 50 percent of the growth factor because of expected declining fuel availability for secondary consumption categories such as this.

Year	1973	1975	1980	1985
Total population	185,338	192,384	210,000	230,700
Growth factor	base	1.04	1.13	1.24
Adjusted growth factor	base	1.02	1.06	1.12
OFHIVEH Fuel Usage (10^3 gal/yr)	5,884	6,002	6,237	6,590

It is to be noted that, since off-highway vehicles are essentially uncontrolled, the 1973 emission factors have been assumed to apply through 1985 (Tables A-2, A-3, A-4).

Table 5-6. EMISSION FACTOR DERIVATION - OFF-HIGHWAY VEHICLES

Category	Fuel usage, $x10^3$ gal	Emission factors, $lb/10^3$ gal.				
		Part.	SO_x	CO	HC	NO_x
Diesel						
Tractor[a]	38	45.7	31.2	119.0	60.7	335.0
Const. equip.[b]	2,000	25.7	31.2	95.3	28.4	397.4
"Other"[c]	1,372	30.1	31.1	94.2	34.7	494.0
Gasoline						
Tractor[d]	65	8.0	5.3	3,260	125.0	151.0
"Other"[e]	2,409	21.4	4.8	3,656	703.0	41.7
Weighted average emission factors		24.9	20.1	1,588	307.3	271.2

[a] Does not take into account non-tractor farm equipment.

[b] Arithmetical average of factors for all heavy-duty equipment.

[c] "Miscellaneous" category factors, including belt loaders, cranes, pumps, mixers, generators.

[d] Does not take into account non-tractor farm equipment.

[e] Arithmetical average of 2 and 4 stroke factors for small, general utility gasoline powered engines.

Subarea Distribution

The calculation of emissions from this category is based almost entirely on population. The allocations of emissions to each grid were, therefore, distributed proportionately to the grid population of each study year. These distributions are shown in Appendices E through Q.

6. COMBUSTION OF SOLID WASTES (CONTROLLED AND UNCONTROLLED)

OPEN BURNING (OPENBUR)

Area-wide Emissions

There are three classifications that should be considered in this category: a) leaf burning outside the urban services area, b) residential on-site burning and c) unintentional structural fires.

a) The residential area outside the urban services area was assumed to include primarily older rural homes, where leaf raking is often not done, and newer suburban development homes, where trees are rarely large enough to produce enough leaves to require raking and burning. This, therefore, was considered a negligible category.

b) In Georgia, open burning in counties with a population greater than 65,000 is prohibited. Chatham county comes under this restriction. However, it is probable that a sizable amount of residential refuse still is disposed of by open burning. Therefore, the policy set forth by GA. DNR of allowing 0.5 lb refuse burned/capita/day was adopted here as being a reasonable estimate. Commercial and industrial open refuse burning were considered negligible.

Total res. refuse combustion (tons/year) = (0.5 lb/cap-day)(365)(185,338)(ton/2000 lb)

= 16,912 tons refuse burned/year.

In computing emission factors for this subcategory, it was assumed that the waste was a mixture of municipal refuse, wood refuse, and landscape refuse and pruning waste. Therefore, the computed emission factors were the arithmetical average of the factors given for these classifications in AP-42. These EF's were further averaged with those pertaining to unintentional structural fires to yield a weighted average set of emission factors for the entire category (Table A-1).

c) Unintentional structural fires in 1973 numbered 1,194 in the county. The data are documented below:

Table 6-1. STRUCTURAL FIRES IN CHATHAM COUNTY - 1973

Location	Incorporated area			Unincorporated area outside city limits			Total - all categories
	Res.	Comm'l	Public use	Res.	Comm'l	Public use	
Bloomingdale[a]	12	-	-	9	-	-	21
Garden City[a]	36	15	9	9	-	-	69
Pooler[a]	14	4	-	9	2	-	29
Port Wentworth[a]	24	-	-	14	-	-	38
Savannah Beach[a]	8	4	2	-	-	-	14
Thunderbolt[a]	8	3	1	-	-	-	12
Vernonburg[a]	No data available						
Savannah[b]	481	-	114	-	-	-	595
Chatham Co.[a]	-	-	-	304	97	15	416
Total	583	26	126	345	99	15	1,194

[a] Source: Personal Communication, Mr. Bill Saxmann, Chatham County - Savannah Metropolitan Planning Commission, and Mr. N.S. Walsh, PEDCo-Environmental Specialists, Inc., September 8, 1975.

[b] Source: Personal Communication, Mr. Schroeder, Savannah Fire Department and Mr. N.S. Walsh, PEDCo-Environmental Specialists, Inc., September 8, 1975.

A general method suggested in Reference 1 to estimate the average number of fires occurring among a populace uses a factor of 4 fires/1000 residents:

Total structural fires = (4 fires/10^3 capita)(185,338) = 741, 38 percent fewer than the actual total of 1,194.

Assuming no catastrophic fires, an average factor of 5 tons of wood burned per fire, an engineering judgement of PEDCo-Environmental, was used to estimate emissions.
Therefore, total wood burned in study area in 1973 equals
(1,194 fires/yr)(5 tons wood burned/fire)
= 5,970 ton/yr

The total fuel combusted in this category then, is 16,912 ton/yr + 5,970 ton/yr, or 22,882 ton/yr .

Emission factors for the structural fires subcategory were derived from the wood refuse table in AP-42 and an overall weighted EF for both subcategories of this source was computed (Table A-1), since it was desired that they be combined as an entity for calculation purposes. These EF's then, were input with the total fuel consumed - 22,882 ton/yr - to the Area 2 program to calculate pollutant emissions:

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
OPENBUR	191.1	2.3	699.0	163.6	34.3

Projections

Leaf burning is expected to remain a negligible factor in open burning outside the urban services area. There are a number of theories that could be postulated to project residential on-site burning emissions. One seemingly obvious one is that as population increases, open burning

increases by the same percentage. However the assumption made in this study was that as population increases, emissions from this category will decrease by the same percentage. The reasoning follows: 1) air pollution control regulations will become more stringent in the future and enforcement policies stricter, 2) more refined methods of solid waste disposal and recycling will be utilized making solid waste less economically feasible to dispose of in a wasteful fashion, 3) urban development and the trend toward multi-family dwellings indicates that less space per capita will be available where burning could occur.

It has been assumed that unintentional structural burning will follow the on-site refuse burning profile, as it is especially difficult to correlate any unintentional occurrence with known quantities and establish meaningful projections. In this case, level of activity is most probably a function of weather, dwelling age and condition, fire department efficiency, type of building materials used, etc. It is reasonable to expect a long range decrease in the number of dwelling fires due to establishment of stricter building codes requiring utilization of more efficient fire retardent materials in construction, and expected upgrading of the downtown sections of the city and razing of older fireprone residences.

Year	1973	1975	1980	1985
Total population	185,338	192,384	210,000	230,700
Growth factor	base	1.04	1.13	1.24
Adjusted growth factor	base	0.96	0.87	0.76
OPENBUR fuel combustion (ton/yr)	22,882	21,967	19,907	17,390

OPENBUR emissions for future years are presented in Tables 2-2 to 2-4 assuming that the same emission factors prevail as in 1973 (Tables A-2, A-3 and A-4).

Subarea Distribution

Computed emissions were allocated to grid cells proportional to each grid's study year population and are tabulated in Appendices E through Q.

INCINERATION (INCINERA)

Area-wide Emissions

A listing of all known non-point source incinerators in Chatham County, the type and quantity of refuse burned in each, and the number of days operated per year was recently compiled by Georgia DNR. This listing is shown in Table 6-2. While the data are representative of 1975, not the base year 1973, they probably provide the best available estimate of the 1973 refuse burning rates for the incinerators still in operation. However, the total refuse burned could be low because several incinerators may have been shut down during 1973 and 1974. Nevertheless, in the absence of more detailed information, it was assumed that the total refuse burned in 1973 equalled that presented for 1975.

Table 6-3 shows the classification system for incinerated wastes, lending definition to the waste type indicators listed by incinerator in Table 6-2. Emission factors then, were selected based on knowledge of these data. Commercial incinerators were assumed to be multiple chamber unless indicated as pathological or otherwise. Sewage sludge incinerators were assumed to be controlled.

Then, to arrive at emissions:

Incinerator emissions (ton/yr) = (lb. refuse burned/day)(days operated/year)(ton/2000 lb)(lb. pollutant emitted/ton refuse burned)(ton/2000 lb)

The total refuse combusted in this category was 5,084 ton/yr and the total emissions are:

Table 6-2. LIST OF NON-POINT SOURCE INCINERATORS IN CHATHAM COUNTY - 1975[a]

Incinerator/location	Grid	Refuse burned, lb/day	Days operated per year	Refuse burned, ton/yr	Type waste	Emission factors, lb/ton					Emissions, ton/yr				
						Particulate	SO_x	CO	HC	NO_x	Particulate	SO_x	CO	HC	NO_x
Winn-Dixie Stores 4607 Habersham Savannah, GA.	28	4,200	350	735	0	7	2.5	10	3	3	2.6	1.0	3.7	1.1	1.1
Winn-Dixie Stores 43 W. Montgomery Cross Savannah, GA.	45	4,200	350	735	0	7	2.5	10	3	3	2.6	1.0	3.7	1.1	1.1
Winn-Dixie Stores 2007 Water Avenue Savannah, GA.	21	4,200	350	735	0	7	2.5	10	3	3	2.6	1.0	3.7	1.1	1.1
Food Town of Price St. Post Office Box 10125 Savannah, GA.	21	70	312	11	1	7	2.5	10	3	3	Neg.	Neg.	Neg.	Neg.	Neg.
Candler General Hospt. P. O. Box 9787 Savannah, GA.	21	500	250	63	1,2,4	8	Neg. (pathological waste)		Neg.	3	0.3	Neg.	Neg.	Neg.	0.1
GA. Regional Hospt. P. O. Box 13607 Savannah, GA.	28	2,940	250	368	1,2	7	2.5	10	3	3	1.3	0.5	1.8	0.5	0.5
M&M Supermarket 4601 Skidaway Rd. Savannah, GA.	35	1,600	312	250	3	7	2.5	10	3	3	0.9	0.3	1.3	0.4	0.4
Winn-Dixie Stores Stiles & Gwinnett St. East City Mall - Hwy.17 Savannah, GA.	20	4,000	312	624	0,1	7	2.5	10	3	3	2.2	0.8	3.1	0.9	0.9
S.S. Kresge K-Mart, Victory Dr. Savannah, GA.	28	3,600	313	563	0,1	7	2.5	10	3	3	2.0	0.7	2.8	0.8	0.8

Table 6-2 (continued). LIST OF NON-POINT SOURCE INCINERATORS IN CHATHAM COUNTY - 1975[a]

Incinerator/location	Grid	Refuse burned, lb/day	Days operated per year	Refuse burned, ton/yr	Type waste	Emission factors, lb/ton					Emissions, ton/yr				
						Particulate	SO_x	CO	HC	NO_x	Particulate	SO_x	CO	HC	NO_x
Abbitt Realty Co. Drayton Towers Apt. Savannah, GA.	21	150	312	23	1	7	2.5	10	3	3	Neg.	Neg.	Neg.	Neg.	Neg.
Andy's Supermarket 8491 Waters Ave. Savannah, GA.	40	2,000	250	250	1	7	2.5	10	3	3	0.9	0.3	1.3	0.4	0.4
Memorial Medical Center Waters Ave. & 63rd St. Savannah, GA.	34	100	260	13	2,3-1	15 (single chamber)	2.5	20	15	2	Neg.	Neg.	0.1	Neg.	Neg.
Food Fair Supermarket Price & Oglethorpe St. Savannah, GA.	21	5,000	250	625	1,2	7	2.5	10	3	3	2.2	0.8	3.1	0.9	0.9
Chatham County Nursing Home 6711 LaRoche Avenue Savannah, GA.	35	180	365	33	1,2	7	2.5	10	3	3	0.1	Neg.	0.2	Neg.	Neg.
Chatham Apartments 609 Abercorn St. Savannah, GA.	14	375	300	56	1,2	7	2.5	10	3	3	0.2	Neg.	0.3	Neg.	Neg.
			Totals	5,084							17.9	6.4	25.1	7.2	7.3

[a] Compiled from data supplied by Georgia Department of Natural Resources.

Table 6-3. CLASSIFICATION OF INCINERATED WASTES[a]

Type of waste								
Type	Description	Typical composition	Approximate composition, % by weight	Moisture content, %	Incombustible solids, %	Btu/lb of refuse as fired	Btu of auxiliary fuel per lb of waste required in combustion calculations	Recommended minimum Btu/lb of furnace input per lb of waste
0		Combustible trash, paper, cardboard, wood, rags, etc.		10	5	8,500	0	0
1	Rubbish	Combustible waste, paper, cartons, trees, wood scraps, floor sweepings, furnishings, domestic, commercial, industrial sources	Rubbish 10% (Cardboard 20%)	25	10	6,500	0	0
2	Refuse	Rubbish and garbage, residential sources	Rubbish 50% Garbage 50%	50	7	4,300	0	1,500
3	Garbage	Animal & vegetable wastes, restaurants, hotels, markets, institutions, commercial, and light industries	Garbage 100% (Rubbish up to 30%)	70	5	2,500	1,500	3,000
4	Animal solid and organic wastes	Carcasses, organic solid organic wastes, fruits, livestock, poultry, animal parts, and similar sources	100% animal and vegetable matter	85	5	1,000	1,000	2,500 50% primary (3 furnace type)
5	Gaseous, liquid or semi-liquid waste	Industrial process wastes	Variable	Depends on process industry involved	Variable according to wastes survey	Variable according to wastes survey	Variable according to wastes survey	Variable according to waste survey
6	Semi-solid and solid wastes	Combustible refuse, pathological, toxic, or gaseous burning equipment	"	"	"	"	"	"

[a] As defined by the Incineration Institute of America.

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Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
INCINERA	17.9	6.4	25.1	7.2	7.3

Projections

There has existed a recent trend to shut down on-site incinerators and use compactors or dumpsters for commercial, institutional, and industrial solid waste disposal. However, this trend probably will moderate because all of the remaining incinerators are expected to become in compliance with air pollution control regulations and will not require expensive upgrading. Most incinerator operators probably will not change their means of waste disposal unless the economics of an alternate disposal method change or the facility moves or is renovated. Also, the possibility of new on-site incinerators exists. Therefore, it has been assumed that solid waste disposal in and emissions from on-site incinerators will remain almost constant over the next ten years at the estimated 1973 level.

Subarea Distribution

The street addresses of all the on-site incinerators are known. Therefore, emissions for 1973 and succeeding projection years have been allocated directly to the appropriate grids by totaling the amount of refuse burned and resulting emissions in each grid. Thus, emissions are tabulated as "additional emissions" under the INCINERA category in the Area 2 Program printouts (Appendices E - Q) and total emission summaries (Tables 2-1 to 2-4).

FOREST FIRES AND AGRICULTURAL BURNING (FFAGBUR)

Area-Wide Emissions

In 1973, forest fires, agricultural burning, and wild fires burned 3,759 acres in Chatham County, according to the U.S. Forest Service.

This is considered to be the best available estimate, although it may be low due to the omission of unreported/unrecorded controlled fires.

There are approximately 114,700 acres of forested land in Chatham County, five-sixths of which is heavy pine timber stands. Available fuel loadings are highly variable due to variations in type and density of growth, weather conditions, and types of fire. The best available estimates of material destroyed per acre under fire in Chatham County were obtained from the U.S. Forest Service and range from 1-2 ton/acre for agricultural burning (consisting mostly of grass, stubble, and winter wheat), to 5-6 ton/acre for forest fires, and 8-9 ton/acre for wildfires. The upper extreme of these ranges was used for calculation of emissions, in order to preserve a "worst case analysis." Table 6-4 summarizes the pertinent data.

Table 6-4. FOREST FIRES AND AGRICULTURAL BURNING IN CHATHAM COUNTY - 1973[a]

Type burning	Acres burned	Average available fuel loading, ton/acre	Fuel burned, ton/yr
Forest fires	1,679	6	10,074
Wildfires	762	9	6,858
Agricultural burning	1,318	2	2,636
Totals	3,759		19,568

[a] Personal communication: Dr. Hough, U.S. Forest Service, Southern Forest Fire Lab, and Mr. N.S. Walsh, PEDCo-Environmental, September 17, 1975.

Emission factors for this category were obtained from AP-42, Supplement 4, and are tabulated in Table A-1. They were input to the Area 2 Program along with the total fuel combusted to calculate total and apportioned emissions. Total emissions from this category are shown below.

Source category	Total emissions - 1973, ton/yr				
	Part.	SO_x	CO	HC	NO_x
FFAGBUR	166.3	0.0	1,369.8	234.8	39.1

Subarea Distribution

Allocation of emissions from FFAGBUR in Chatham County to grid cells was done by the Area 2 Program proportional to the forested acreage per grid. The total forested watershed acreage, exclusive of cropland, populated, or highway acreage, was obtained from the Metropolitan Planning Commission. The forested acreage in each grid was estimated from USGS maps.

Projections

Climatic factors will heavily influence the occurence of unintentional forest and field fires on a year to year basis and predicting future trends is quite difficult. Data to indicate projections of acreage destroyed by these types of burning do not exist. Emissions from this category, however, may decline as suburban development encroaches on heretofore undeveloped forested land and the land available for burning decreases. Based upon total population increases of the grids in the County containing forested acreage, the acreage burned for each projection year was adjusted downward by a factor equal to the product of the percent population increase and the ratio of the urban to the forested area.

FFAGBUR growth factor =

$$1 - \left(\frac{\text{urban area}}{\text{forested area}}\right)\left(\frac{\text{future yr pop'l - base yr pop'l}}{\text{base yr pop'l}}\right)$$

$$= 1 - \left(\frac{50\ \text{mi}^2}{173\ \text{mi}^2}\right)\left(\frac{\text{future yr pop'l} - 185{,}338}{185{,}338}\right)$$

Year	1973	1975	1980	1985
Population of grids in areas of county containing forested acreage	185,338	190,000	210,000	230,700
FFAGBUR growth factor	base	0.993	0.96	0.93
FFAGBUR fuel usage (ton/yr)	19,568	19,431	18,785	18,198

7. OTHER SOURCES

EVAPORATIVE LOSS SOURCES (EVAPLOS)

Area-wide Emissions

This category considers emissions from gasoline handling losses, dry cleaning solvent losses, and surface coating and miscellaneous solvent-use operations. No local survey data was available to estimate HC losses from these sources; therefore, procedures outlined in Reference 1 were employed.

Solvent Use - Emissions were computed under this subcategory for dry cleaning operations only. From the HC per-capita emission factor[1] and the per ton emission factor,[10] a per-capita use factor was developed, due to the necessity, when using the Area 2 Program, to enter the fuel usage total and emission factor in compatible units.

$$\text{Per capita use factor} = \frac{\frac{2 \text{ lb HC emitted}}{\text{capita-yr}}}{257.5 \frac{\text{lb HC emitted}}{\text{ton solvent used}}}$$

$$= 15.5 \frac{\text{lb solvent used}}{\text{capita-yr}}$$

Solvent use emissions for Chatham County in 1973 are:

$$\text{Solvent used (ton/yr)} = \frac{(185{,}338)\left(\frac{15.5 \text{ lb solvent}}{\text{capita-yr}}\right)}{2{,}000 \text{ lb/ton}} = \underline{1{,}486 \text{ ton/yr}}$$

The emission factor for this subcategory is the average of the published (AP-42) factors for petroleum and synthetic solvents - 257.5 lb/ton.

Surface Coating Operations - The per-capita solvent use factor[1] - 28 $\frac{\text{lb solvent used}}{\text{capita-yr}}$ was used to calculate total solvent use:

$$\text{Solvent used (ton/yr)} = \frac{(185{,}338)(28 \frac{\text{lb solvent used}}{\text{capita-yr}})}{2{,}000 \text{ lb/ton}}$$

$$= 2{,}595 \text{ ton/yr}$$

The emission factor for this subcategory is the average of the factors for 5 surface coatings[10] - 1,164 lb/ton.

Gasoline Handling Losses - The splash filling and liquid spillage losses associated with the filling of motor vehicle gas tanks were the only emission sources considered under this subcategory. Emissions from petroleum storage tanks were assumed to have been accounted for by point source inventories.

From county fuel sales reports for 1973, gasoline usage is:

Total on-highway gasoline consumption = $92{,}696 \times 10^3$ gal/yr
Total off-highway gasoline consumption = $2{,}474 \times 10^3$ gal/yr
Total gasoline usage in study area = $95{,}170 \times 10^3$ gal/yr

$$= \frac{(95{,}170 \times 10^3 \text{ gal/yr})(6.17 \text{ lb/gal})}{2{,}000 \text{ lb/ton})}$$

$$= 293{,}600 \text{ ton/yr}$$

It is assumed that all the gasoline sold in the area but not consumed there equals that sold elsewhere but consumed in the area.

The emission factor for this subcategory equals:

$$\begin{aligned} EF &= 11.0 \text{ lb}/10^3 \text{ gal pumped (vapor displacement loss)} \\ &\quad +0.67 \text{ lb}/10^3 \text{ gal pumped (liquid spillage loss)} \\ &= 11.67 \text{ lb}/10^3 \text{ gal gasoline pumped} \end{aligned}$$

Converting units:

$$EF = (11.67 \text{ lb}/10^3 \text{ gal})\left(\frac{10^3 \text{ gal}}{3.1 \text{ T}}\right) = 3.8 \frac{\text{lb HC emitted}}{\text{ton gas pumped}}$$

The overall emission factor for this category is a weighted average of the factors for the above 3 subcategories, since a combined input to the Area 2 Program was desirable. The total solvent/gas used under this category is 297,631 ton/yr. The derivation follows:

$$\overline{EF} = \frac{(1,436)(257.5)+(2,595)(1,164)+(293,600)(3.8)}{297,631}$$

$$= 15.1 \frac{\text{lb HC emitted}}{\text{T solvent used}}$$

Total hydrocarbon emissions from evaporative loss sources equal:

Source category	HC emissions - 1973, ton/yr
Solvent use	185
Surface coating	1,510
Gasoline handling	558
Total	2,253

Projections

It is not anticipated that solvent usage rates will fluctuate greatly during the period of accountability of this study. It always remains a possibility, however, that more refined control measures will be implemented for this essentially uncontrolled category. In the absence of more sophisticated estimation techniques, projections for all evaporative loss sources are based solely on the total population increase in the study area. Projected solvent/gas usage and corresponding EVAPLOS emissions are:

Year	1973	1975	1980	1985
Total population	185,338	190,000	210,000	230,700
Growth factor	base	1.02	1.13	1.24
Solvent/gas usage (ton/yr)	297,631	303,583	336,323	369,062
Total HC emissions (ton/yr)	2,253	2,298	2,546	2,794

Subarea Distribution

Emissions were distributed to grid cells proportional to the total population of the cells during the respective study year (Appendices E through Q).

FUGITIVE DUST-UNPAVED ROADS (FDUNPRD)

Area-wide Emissions

There were 162.3 miles of unpaved roads in Chatham County reported in the 1973 inventory of roads prepared by the Georgia DOT.* The mileage of unpaved roads in each grid was estimated from USGS topographic maps, this estimate totaling 382.7 mi. It is highly probable that the DOT inventory is accurate and the excess in estimated grid mileage is reflected on USGS maps because the most recent survey data have not yet been incorporated thereon. However, unaccounted for in the DOT survey may be city alleys and roads in outlying residential developments that are not paved until construction is complete. Nevertheless, for apportioning purposes, it was assumed that the actual complement of unpaved road mileage per grid was in the same proportion to those values actually determined from USGS maps.

Transportation department personnel provided a state-wide estimate of average daily traffic (ADT) on county locally controlled roads - both paved and unpaved - of 80 vehicles/day.* The estimated ADT on unpaved roads alone was unavailable. Therefore, it was concluded that this estimate would unrealistically represent the ADT on unpaved roads, tending to more heavily weight the paved surfaces, by virtue of their greater number. Therefore, a figure of 23 vehicles/day,+ derived from estimates compiled by the Utah State

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* Personal Communication: Mr. Joe Lindsay, Georgia Department of Transportation, Road Life Division, and Mr. N.S. Walsh, PEDCo-Environmental, September 8, 1975.

+ Personal Communication: Mr. Lester Jester, Utah State Department of Highways, Systems Planning Division, and Mr. Tony Wisbith, PEDCo-Environmental, June 4, 1975.

Department of Highways was used. This value represents ADT on non-surfaced roads in 5 counties in the Salt Lake City area and was judged a reasonable estimate. More accurate, locally derived data was unavailable.

The annual VMT then, is:

$$\text{VMT (annual)} = (23 \text{ veh/day})(162.3 \text{ mi roads})(365)$$

$$= \underline{1{,}363 \times 10^3 \text{ VMT/yr}}$$

The emission factor for unpaved roads was obtained from the EPA report, Development of Emission Factors for Fugitive Dust Sources,[27] assuming a gravel roadbase with an average silt content of 12.5 percent, and an average speed of 30 mph on the roads.

$$\text{EF (unpaved roads)} = 0.81\, s\left(\frac{S}{30}\right) = 0.81(12.5)\left(\frac{30}{30}\right)$$

$$= 10.1 \text{ lb/VMT}$$

This value was corrected downward to account for the relative climatic factors between the area in which the factor was developed and Savannah, and by the annual percentage of time during which no emissions would occur because of rainfall, to yield a revised emission factor of 3.53 lb/vehicle-mile traveled.

The correction factor derivations are:

Climatic factor:

C_1 (Franklin County, Kansas)[27] = 0.1

C_2 (Savannah)[27] = 0.05

C (relative) = C_2/C_1 = 0.5

Surface moisture:

No. days with >0.01 in. precipitation[27] = 110

$$EF\ (\text{unpaved roads})_{\text{corrected}} = (10.1\ \text{lb/VMT})(0.5)\left(\frac{365-110}{365}\right)$$

$$= 3.53\ \text{lb/VMT}$$

$$= \underline{3{,}530\ \text{lb}/10^3\ \text{VMT}}$$

The resulting area-wide emissions were then calculated and apportioned by the Area 2 Program.

$$\text{FDUNPRD Emissions} = (1{,}363 \times 10^3\ \text{VMT/yr})(3{,}530\ \text{lb}/10^3\ \text{VMT})\left(\frac{\text{ton}}{2000\ \text{lb}}\right)$$

$$= \underline{2{,}406\ \text{ton/yr}}$$

Projections

As indicated above, there is almost no information available on present traffic volumes on the unpaved roads, much less data on discernible trends toward increased or reduced traffic volumes. Nevertheless, observations can be made regarding certain classifications of unsurfaced roads, leading to the conclusion that the total VMT may remain constant over the next 10 years.

First, most of the county maintained unpaved roads lead to rural residences, farming districts, or recreational areas and forested land. Therefore, volume on these roadways is unlikely to increase proportionately with total traffic volume for the counties. Secondly, if traffic on a road were to increase significantly as a result of a new trip generator along the road, the road would probably be paved at that time. Thirdly, roads in new residential areas that are to be paved by developers when building construction

phases are completed will be replaced by similar under-construction developments in future years.

For lack of any definitive information, it has been assumed that traffic volume on unpaved roads will remain constant over the next 10 years, with the total mileage of unpaved roads decreasing by about 5 percent annually.*

Projections then, are:

Year	1973	1975	1980	1985
% 1973 unpaved roads remaining	100	90	65	40
Annual VMT ($x10^3$)	1,363	1,227	886	545
FDUNPRD emissions (ton/yr)	2,406	2,165	1,564	962

Subarea Distribution

All fugitive dust emissions from unpaved roads were allocated directly to grid cells proportional to the measured mileage of unpaved roads contained in each.

* Personal Communication: Mr. J. Lindsay, Georgia Department of Transportation, Road Life Division, and Mr. N.S. Walsh, PEDCo-Environmental, September 8, 1975.

FUGITIVE DUST - PAVED ROADS (FDPAVRD)

Area-wide Emissions

Initially, inclusion of this source category in the area source inventory was not intended, due to the paucity of available data and procedures on which to base emission estimates. However, this source is becoming recognized as a significant contributor to the total particulate loading in many areas, and it was concluded that some quantitative estimate should be included, in spite of the paucity of pertinent data.

It must be emphasized that the derivations presented below do not have the same accuracy as calculations in other sections of this report, and the resulting emission estimates are only order-of-magnitude values. In recognition of this and in anticipation of future refinements of these estimates, this source category has been separated from the remainder of the categories in all data summaries.

Seattle Study - Only one study was found in which any pertinent data have been published.[28,29] From a single test of a paved road that was flushed and swept regularly, field sampling showed an emission rate of 0.14 lb/VMT, with 0.0055 lb/VMT (2.5 grams/VMT) below 10 micrometers in size. Three tests of dusty paved roads, in areas with construction projects or near unpaved roads where dirt was tracked onto the pavement, indicated an average emission factor of 0.83 lb/VMT with 0.17 lb/VMT (77 grams/VMT) under 10 micrometers.

A major concern with these reported values is the sampling method used--impaction samplers were mounted in an array on

a trailer towed behind the test vehicle. Most of the resuspended material collected in the area of turbulence on the roadway would have an impact on air quality only in this limited area and not on a regional scale. This sampling method does not allow for settling and, more importantly, it may pick up particulate matter generated by many preceding vehicles, not just the test vehicle.

Example emission calculations presented in Appendix 4 to the publication[28] show substantial reductions from the emission rates cited above, although these reductions are not made for the purpose of compensating for the sampling method. In calculating annual emissions, the authors assume that:

1. dust is emitted from the road 200 days/year (in Seattle);
2. the "dry emission factor" is 30% less than the values presented;
3. average dusty paved roads emit at only 50 % of the rate for the three roads tested; and
4. the sample of under 10 microns is comparable to the suspended particulate emitted.

No data are presented to support any of these assumptions.

If the emission factors and assumptions from this study are applied to Savannah data, and it is additionally assumed that roads in Savannah would be similar to the tested street that was cleaned regularly, the following results are obtained:

$$EF \text{ (corrected)} = (0.0055 \text{ lb/VMT})(0.7)\left(\frac{365-110}{365}\right)\left(\frac{10^6}{10^6}\right)$$

$$= \underline{2{,}693 \text{ lb}/10^6 \text{ VMT}}$$

Note that the emission factor is corrected for surface moisture, i.e., no emissions occur on days with >0.01 in. precipitation (110).

The 50 percent correction factor was not used, since it applied specifically to uncleaned streets.

Thus, total emissions are:

$$\text{FDUNPRD Emissions} = (1{,}025 \times 10^6 \text{ VMT/yr})(2{,}693 \text{ lb}/10^6 \text{ VMT})\left(\frac{\text{ton}}{2{,}000 \text{ lb}}\right)$$

$$= \underline{1{,}380 \text{ ton/yr}}$$

Of course, the total VMT traveled and the EF were input to the Area 2 Program to calculate apportioned emissions (Appendices E through Q).

Chicago Study - The American Public Works Association (APWA) is presently conducting a study to determine the environmental benefits of improved street cleaning. In conjunction with the Chicago Department of Environmental Control and IIT Research, they are microscopically examining hi-vol filters from street canyon exposures in an attempt to determine the origin of the particulate matter. They have not yet reached final conclusions, but preliminary indications* are that auto exhaust accounts for only 25 percent of motor vehicle impact, with the remainder from resuspended dust and tire wear. Using this 25 percent factor and particulate emission factors from Chapter 5, an average emission factor for the road dust portion can be approximated:

$$(0.25)(\text{TMVPEF})^+ = 0.34 \text{ grams/VMT}$$

$$\text{TMVPEF} = 1.36 \text{ grams/VMT}$$

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* Personal Communication: Mr. William J. Murphy, APWA, and Mr. Ken Axetell, PEDCo-Environmental, March 19, 1975.

\+ Total motor vehicle particulate emission factor.

FDPAVRD = TMVPEF - exhaust - tire wear - brake wear

= 1.36 - 0.34 - 0.20 - 0.02

= 0.8 grams/VMT

With this factor, fugitive dust from paved roads in Savannah would equal 993 ton/yr. For an initial estimate, it is proposed that the value from the Seattle Study (1380 ton/yr) be used in order to preserve the "worst case" analysis.

Projections

At this point, it cannot even be established that VMT is the best indicator of dust emissions from paved roads. Emissions are possibly more closely related to miles of road surface or some other parameter. However, since the current emission estimates are based on VMT, future emissions can reasonably be assumed to increase proportionately to VMT. These emissions are:

Year	1973	1975	1980	1985
Estimated total VMT ($\times 10^6$)	1,025	1,107	1,302	1,404
VMT growth factor[a]	base	1.08	1.27	1.37
FDPAVRD emissions (ton/yr)	1,380	1,490	1,753	1,891

[a] Personal Communication: Mr. Madden, Georgia Department of Transportation, Urban Planning, and Mr. N.S. Walsh, PEDCo-Environmental Specialists, INC., September 5, 1975.

Subcounty Distribution

To maintain consistency, dust emissions from paved roads have been allocated based upon the total VMT in each grid for the study years. The distributions of estimated emissions from dust on paved roads are shown in Appendices E through Q.

FUGITIVE DUST - AGRICULTURAL TILLING (FGDAGTIL)

Area-wide Emissions

Windblown dust from tilled fields was estimated by use of the wind erosion equation, a procedure explained in detail in Reference 27. Briefly, a separate emission factor is established for each crop type in an area as a function of resistance to wind erosion provided by that crop and plowing methods normally used with it. The emission factors also vary according to the common soil types characteristic of agricultural land in an area and its climate.

The fugitive dust component generated by the actual implement tilling operation has also been estimated. Emission calculations for tillage operations account for the limited periods when the farming equipment is actually used in the fields; they do not account for the lower level emissions that occur periodically as a result of wind erosion across the fields. Annual emissions from tilling may be quite small in comparison with suspended particulate emissions generated by wind erosion.

The total acreage devoted to harvested cropland in Chatham County in 1973 was 1,700 acres,[30] consisting of soybeans, and corn. The acreage harvested by commercial truck farms and other sources is negligible, as is acreage devoted to hay. Actually, there is very little agricultural activity in the county.

The modified form of the wind erosion equation is:[27]

$$E_w \text{ (tons/acre/year)} = aICKL'V' (\pm 5\%)$$

where,

a, I, C, K, L', V' are quantities and factors defined in Table 7-1, in which windblown dust emissions calculations from the tilled acreage in the county are presented in tabular form. The total particulate emissions from the windblown component are seen to be 32.1 ton/yr.

The emission factor for tillage operations is estimated by the following equation:[27]

$$E_t(\text{lb/acre}) = \frac{1.4s(S/5.5)}{(PE/50)^2} \quad (\pm 15\%)$$

where,

S = implement speed (mi/hr) - assumed to be 5.5 mph

s = silt content of soil (%) - assumed to be 10%

PE = thornthwaite's precipitation-evaporation index
= 92 for the study area

The calculated tillage EF then, was 5.8 lb/acre. Fugitive dust emissions were then calculated:

FDAGTIL emissions (ton/yr) =
(5.8 lb/acre)(1700 acre)(3 tillings/yr)(ton/2000 lb)
= 14.8 ton/yr

The total fugitive dust emissions from agricultural activity are then:

FDAGTIL emissions $_{\text{total}}$ (ton/yr) = 32.1 + 14.8
= 46.9 ton/yr

Table 7-1. FUGITIVE DUST EMISSIONS FROM AGRICULTURAL FIELDS DUE TO WIND EROSION - 1973

County	Crop	A, acres	L, field length	V, vegetative cover	I(ton/ac-yr), based on soil type[a]	C, climatic factor	K, surface roughness	L', length factor	V', vegetative factor	E=AaICKL'V' windblown dust emissions by crop, ton/yr[b]
Chatham	Soybeans	880	2000/2	250	56	0.05	0.6	0.75	0.6	16.6
	Corn	820	2000/2	500	56	0.05	0.6	0.75	0.6	15.5
Total		1700								32.1

[a] The primary soil type within the study area is sandy to silty clay loam underlaid by 3 to 4 inches of sand atop a clay subsoil.

[b] where a = portion of total wind erosion losses that would be measured as suspended particulate, estimated to be 0.025.

Subarea Distribution

According to the Chatham County Agricultural Extension Agent, the major portion of the limited agricultural activity prevails in the northern part of the county near Pooler (Grid 5, 8) and out U.S. 17 near Richmond Hill (Grid 42).* The total emissions from this activity were apportioned to these grids on a 25/25/50 basis and added to the Area 2 Program as "additional emissions" in the FDAGTIL category.

Projections

In the years ahead, the state expects a 30 percent increase in soybeans harvested and a 5 percent increase in corn.+ However, a decrease in total acreage harvested is also forecast as urban land development encroaches further into traditional farm areas.

Quantitative projected estimates specific to the crops in Chatham County could not be obtained, but subjective indications were translated into a 10 percent reduction of total harvested acreage between 1975 and 1980 followed by another 10 percent by 1985, with the 1975 harvested acreage equalling that of 1973. Projected and distributed particulate emissions are summarized as follows:

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* Personal Communication: Mr. Meyers, Agricultural Extension Agent, Chatham County Extension Office, and Mr. N.S. Walsh, PEDCo-Environmental, September 30, 1975.

+ Personal Communication: Mr. Mike Hammer, U.S. Department of Agriculture, Statistical Reporting Service, and Mr. Tom Bertke, PEDCo-Environmental, May 30, 1975.

County	Year	Acres harvested	Total emissions, ton/yr	Grid emissions, ton/yr-grids 5/8/42
Chatham	1973	1,700	46.9	11.7/11.7/23.5
	1975	1,700	46.9	11.7/11.7/23.5
	1980	1,530	42.2	10.5/10.5/21.2
	1985	1,360	37.5	9.4/9.4/18.7

The total predicted emissions are 46.9 ton/yr in 1975, 42.2 ton/yr in 1980, and 37.5 ton/yr in 1985.

FUGITIVE DUST - CONSTRUCTION (FDCONST)

Area-wide Emissions

For purposes of estimating fugitive dust emissions, three different types of construction were identified: commercial/industiral/institutional, residential, and highway. The Chatham County Chamber of Commerce, Metropolitan Planning Commission, and Zoning Administration were contacted in an attempt to acquire listings of building projects, their size and location, completed in Chatham County in 1973. After repeated queries, it was concluded that this data was unavailable, thus making the estimation of emissions from this source impossible.

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